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The Design of the Panama Canal Towing Locomotives*

Full information on the design of 40 towing locomotives used at the Panama Canal has recently been disclosed by the government and the manufacturers.† From the mass of available details, the following important ones have been selected.

According to a recent order of Col. G. W. Goethals, Governor of the Panama Canal, six locomotives will ordinarily be used for towing a vessel through the locks, three on each side of the lock. Two will be forward for towing and steadying, two amidships for towing and checking headway, and two aft for steadying and checking. The traction while towing is secured with a pinion and rack rail and not by adhesion. The rack is not used on the return track except on the inclines from one level to another where the 44% grade requires it. Three-phase 25-cycle 220-volt alternating current is supplied to the locomotive through an underground contact system; current is collected by a plow carried on the locomotive. The towing system was designed and patented by Edward Schildhauer, Electrical and Mechanical Engineer of the Isthmian Canal Commission.

The locomotives finally employed are designed with the following operating characteristics: Towing speed, 0 to 2 mi. per hr.; speed running free, 0 to 5 mi. per hr.; cables paid out or wound in at low speed under full pull of 25,000 lb., locomotive running or standing; cable paid out or coiled in at high speed with tow line taut, locomotive running or at rest.

The working parts of the locomotive are supported by two longitudinal upright side frames of cast steel connected by transverse beams. The pedestals for the two wheel axles are of the usual locomotive type with vertical parallel jaws and springs on the tops of the journal boxes.

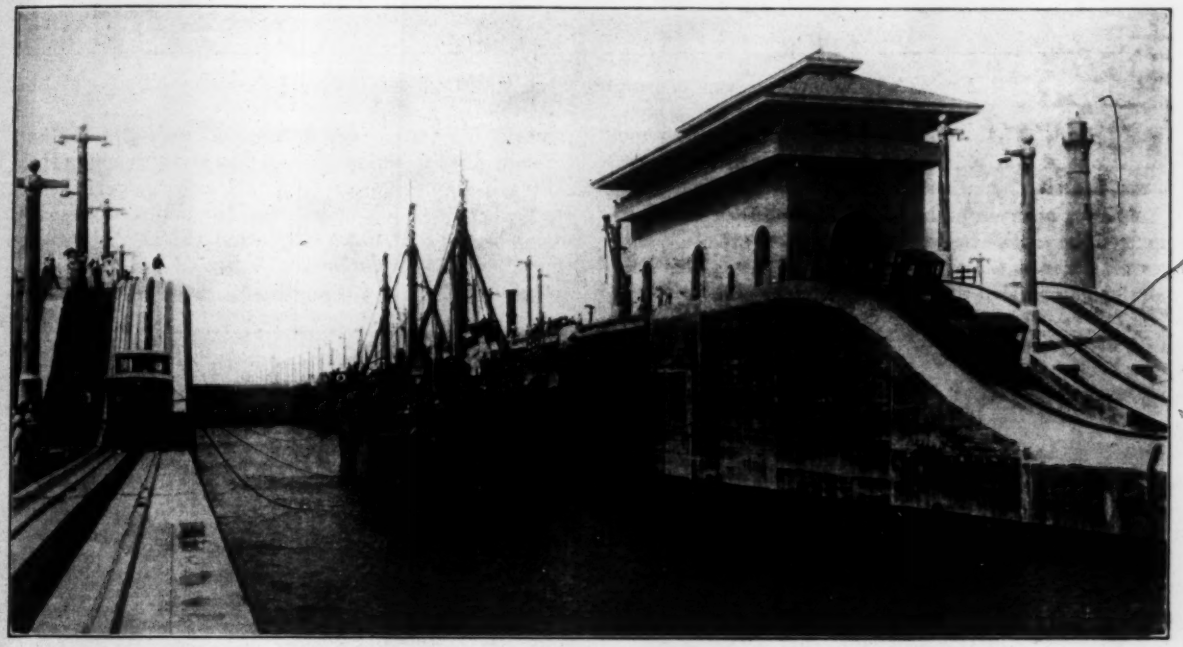

FIG. 1. U. S. TENDER LEAVING UPPER EAST CHAMBER AT GATUN LOCKS

Each axle is driven by its own motor, independent of the other, the construction being identical at both ends of the locomotive. The tractor units are separate from the locomotive frame, and one is shown in Fig. 3. The platform bearing the motor is carried at one end by suspension brackets in a bearing on the axle and supported at the other end by springs on the locomotive frame. The brackets support bearings for a transverse jack shaft and a countershaft, both parallel to the driving axle. The motor is a three-phase slip-ring steel-mill induction type, driving the countershaft through a spur gear and pinion. This in turn similarly drives the jackshaft. The outer side of a spur gear on the jackshaft is made as a tooth

*From information supplied by the General Electric Co., manufacturers of the locomotives.

†The first designs were noted in "Engineering News," Mar. 21, 1912. The trial unit built according to these plans was not satisfactory, so that an alternative design of the General Electric Co. was later accepted. A few preliminary notes on this appeared in "Engineering News," Apr. 9, 1914.

clutch engaging side teeth of a similar gear carried on a loose sleeve around the same jackshaft. When these two gears are connected by the clutch, the sleeve gear then meshes with a wide pinion on the running axle. With this transmission in action, the locomotive is driven solely by the adhesion of the running wheels. For traveling on the rack rails in towing or at an incline there is a heavy cog wheel on a sleeve around the running axle. This sleeve carries a gear which meshes with a pinion loose on the jackshaft, but turning with it when a jaw clutch is thrown in. The driving clutches do not necessarily engage when first thrown, but the operator's handles are moved their full stroke and locked; heavy springs on the clutch arms throw the clutches when aligned.

A powerful drum brake is provided on each motor and none on the truck wheels, since the motors are at all times geared either to the axles or the cog wheels This brake is solenoid operated so that when current is turned on, to energize the motors, the solenoid core is lifted and the brakes released. The first point of the controller releases the brakes without applying power to the motors, thereby providing a coasting point. But if the motor current is shut off, intentionally or accidentally, the solenoid core drops by gravity and its weight works through the brake levers to check the motor and locomotive. This action is strong enough to stop the locomotive within two revolutions of the wheels. The brakes may also be applied manually.

The drum on which the tow cable is wound is located midway between the ends and above the upper member of the side frame. The hub of the drum moves on the hub of a spider which rotates on a column rising from a pedestal supported on a base plate carried by the frame of the locomotive. The spider carries a large internal gear and is driven by one or other of two motors working through vertical pinion shafts. The motor for high-speed coiling has a bevel-gear drive and remains permanently engaged. The other motor, used for taking in the cable under load, has a worm drive, and this is disconnected when the drum is not in use.

There is a friction connection between the spider and

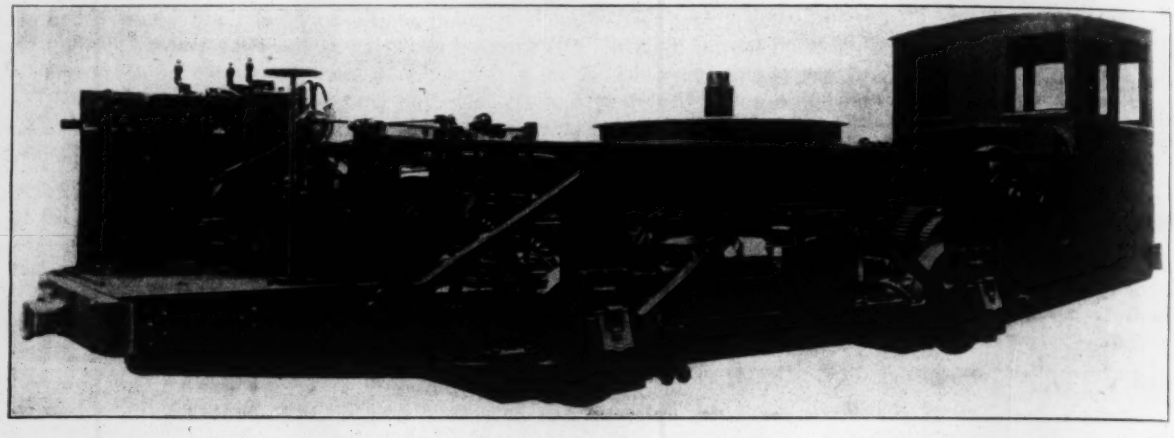

FIG. 2. PANAMA TOWING LOCOMOTIVE WITH ONE CAB AND COVERS REMOVED

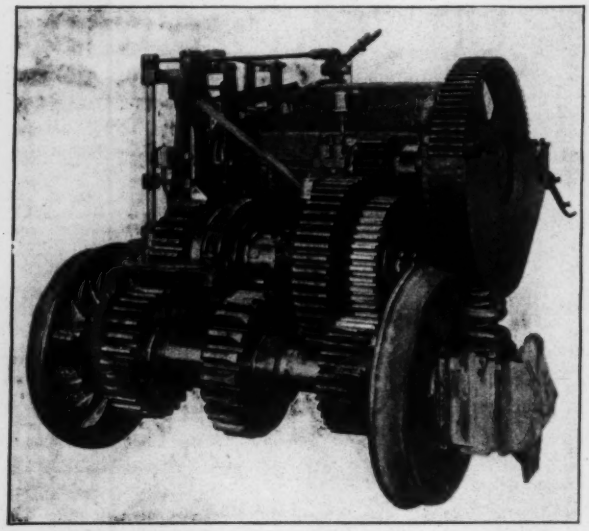

FIG. 3. TRACTION UNIT OF PANAMA LOCOMOTIVE

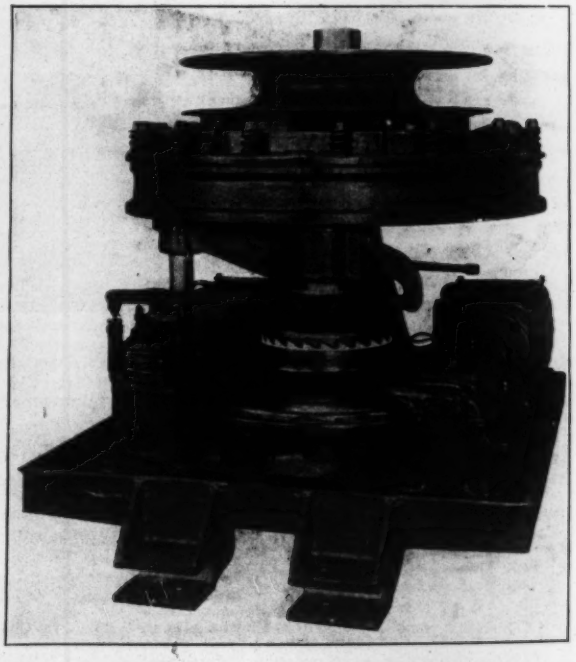

FIG. 4. WINDLASS UNIT AND BASE, PANAMA LOCOMOTIVE

the drum. This consists of two special-alloy rings mounted on the spider and bearing on a steel disk fastened to the drum. Maximum allowable tension on the tow line is fixed by the pressure between these disks and ring, and is adjusted by changing pressure on spiral springs carried by a clamping ring.

A guide, to direct the cable as it pays out and winds in, revolves on the axis of the drum. This has an upper and outer member carrying grooved horizontal rollers, and an inner one nearer the drum carrying vertical smooth-faced rollers. The downward thrust of the cable on the guide is transmitted directly to the locomotive side frame by roller supports running in a circular channel concentric with the drum.

To resist the tendency of the locomotive to tip with maximum load on the cable, two horizontal flanged wheels are between each pair of running wheels engaging the vertical sides of the track rack. These flanged wheels are carried on heavy longitudinal bars whose inner ends are pivoted to the base of the locomotive, so that the bars can move horizontally.

Following are the principal data of the locomotives:

Weight	86,300 lb.
Length, over all	32 ft. 2½ in.
Width	8 ft.
Height, over cab	9 ft. 3in.
Maximum tractive effort	47,800 lb.
Towing speed	2 mi. per hr.
Free speed	5 mi. per hr.
Tow-line pull	25,000 lb.

Sewage-Treatment and Garbage-Reduction Works for Akron, Ohio

Sewage-treatment works and a garbage-reduction plant are now under construction by the City of Akron, Ohio, with provision for combining the sewage sludge with the garbage tankage for manufacture into a fertilizer base. The site is at the junction of the Big and Little Cuyahoga rivers, alongside the Ohio Canal and near the Baltimore & Ohio R.R. tracks, about two miles north of Akron.

The sewage flows to the works by gravity. The plant includes screens and grit chambers, primary two-story sedimentation tanks, control chambers, sprinkling filters, secondary settling tanks, a sludge pump-house, sludge presses and sludge beds, and an industrial railway for conveying the sludge.

The population of Akron in 1910 was 69,067. The sewage works were designed for a population of 150,000, at 100 gal. per capita. The sewers are nearly all on the separate plan. In the central part of the city the sewers are combined, but separate sewers are being provided here as speedily as is possible.

Special features of the grit chamber are (1) adjustable steel vanes, hinged from the sides of the chamber so that a constant predetermined velocity, sufficient to prevent deposit of organic matter, may be obtained, and (2) an overhead monorail with chain hoist and bucket for removing grit either to a wagon or to an industrial track.

From the grit chamber the sewage flows by gravity through open flumes to four groups of two-story tanks. Each group consists of three rectangular tanks, having two flow channels. Elasticity of flow through the two-story tanks is obtained by stop planks placed in the inlet and outlet ends.

The central control chamber consists of four tanks, each of which contains a 30-in. siphon. Each tank is divided into 32 compartments of various depths, arranged to give a constantly varying head and a uniform distribution over the sprinkling filters.

There will be eight sprinkling filters, each one acre in area, containing 6 ft. of either slag or stone. The underdrains will be of half tile, with a curved notch in each side.

The secondary settling tanks will be six in number, one story, open top with trapezoidal sections both transversely and longitudinally, built in excavation.

The sludge from the secondary tanks will flow by gravity to a sludge well and be lifted by a centrifugal pump to the influent channel of one group of primary tanks for further digestion. The sludge from the primary or two-story tanks will gravitate to horizontal steel tanks adjacent to the settling tanks for final disposition by one of two means: (1) The sludge may be forced by compressed air to steel storage tanks in the press house, and again forced by the same means to a Sweetland sludge press, where a large percentage of the contained moisture will be removed; or (2) the sludge may be forced to open sludge-drying beds, from which the industrial railway already mentioned would convey it to the garbage-reduction works. It is expected that during warm weather, or say, from six to eight months in the year, more sludge will be dried upon the beds than in the press, which will be most useful in the winter.

A dike around the plant will protect it from high water and there will be a check valve on the 48-in. effluent pipe. A by-pass just above the control chambers will make it possible to send the primary-tank effluent directly to the Cuyahoga River.

In preparing the site the course of the Little Cuyahoga River was diverted by digging a small channel a third of a mile in length and letting the natural flow of the stream do the rest.

As has been stated, the garbage-reduction works is adjacent to the sewage-works. A railway leads to the two plants. The garbage will be unloaded from railway cars or from wagons onto a platform adjoining the green-garbage building. From here it will be conveyed to the main building and discharged into the digestors, of which there are five, each of five tons capacity. After steam cooking, the garbage will go to a 5x40-ft. direct-heat drier, and then to a 5x18-ft. horizontal percolator.

The grease will pass to separating and settling tanks, and the water to a double-effect evaporator. The gases will go through scrubbers and to the boiler furnaces. Screening, grinding and conveying machinery will be provided.

The principal contractor for the sewage-works is E. McShaffrey & Sons Co., of Akron. The Duquesne Construction Co. has the contract for excavation and grading. The garbage-reduction equipment is being supplied and erected by the Kilby Manufacturing Co., of Cleveland, Ohio, and the buildings for the reduction works are being put up by J. C. Devine, of Alliance, Ohio.

R. Winthrop Pratt, Hippodrome Building, Cleveland, Ohio, is consulting engineer for Akron for both the sewage-works and garbage-reduction plant, and W. J. Springborn, now of New Bedford, Mass., is associated with him in the design of the garbage plant. G. W. Knight is principal assistant engineer on design and is in immediate charge of construction of the plants.

The City Tunnel of the Catskill Aqueduct

By Walter E. Spear*

SYNOPSIS—This tunnel will ultimately deliver 500 millions of gallons daily, through uptake shafts, to the great arterial water mains of the city, connecting with Richmond Borough by means of a submerged pipe line beneath The Narrows. The tunnel proper is 17.7 miles long and from 15 to 11 ft. in diameter. Its depth in some places is 700 to 800 ft. below the surface of the ground and it is never less than 150 ft. below the surface of sound rock. Previous articles have (Part I, Jan. 14, 1915) outlined the project and (Part II, Jan. 21, 1915) described the work of shaft sinking. This article describes the methods of tunnel excavation. Interesting and valuable data are presented in tabular form.

III. Tunnel Excavation

While the driving of the City Tunnel did not present as many difficulties and uncertainties as the sinking of the shafts, the excavation of the tunnel, in point of cost and length of time required, was the largest item of the entire undertaking, and the plant required to do the work, though in general of standard design, contained much that was unusual from the circumstances of the work in the midst of a large city. Realizing its responsibility to the community, the Board of Water Supply made every effort to minimize the annoyance which must result from the work in the vicinity of the tunnel shafts. For example, it was provided in the contracts that electric power be used as far as practicable in place of steam, in order to avoid the noise and dirt arising from the operation of steam plants. Electric power supplied by the New York Edison Co. and its subsidiaries and by the Edison Electric Illuminating Co., of Brooklyn, was accordingly used to drive all permanent equipment, including most of the compressor plants, all shaft hoists, pumps (except air-driven pumps), blowers and the motors on stone-crushing plants as well as those of the concreting plants later installed. Shafts and tunnels were lighted by electricity.

The difficulties and expense of conveying compressed air through the streets from one shaft to another led to the adoption of independent electrically driven compressor plants at each shaft, except in the northerly section, Contract 63, where conditions approximating those outside the city exist and a central steam-driven compressor plant was erected, and except in a section in Central Park where it was possible to supply three shafts of Contract 66 from a single electrically driven plant through air mains laid in the transverse roads and the sidewalk of Central Park West. The size, type and capacity of the compressor plants installed for tunnel excavation are shown in Table IV. This brings out the interesting conclusion that, with the losses of air that occur in the mains and in the drills and connections at the headings, and with the necessary use of high-pressure air for ventilation, not much less than 2000 cu.ft. of free air per min. should be provided, for tunnels of this size, in order to maintain sufficient pressure to drill up two headings simultaneously with piston drills of the largest size. For the independent plants at each shaft, the plan adopted on Contract 67 of two compressors, one smaller than the other, appeared to be preferable to a single unit, because the smaller of the two machines could be run more economically, when only a small amount of air was required, and one of the two could always be depended upon to be in operation. The amount of energy a single shaft required for all purposes during tunnel driving amounted to 40 to 50 kw.-hr. per cu.yd., exclusive of trimming, and the peak loads ranged from 300 to 400 kw.

Besides the ventilation furnished by the exhaust from the drills and by the air blown into the headings from the high-pressure lines after blasting, additional ventilation was provided at all shafts by motor-driven blowers installed at the shaft heads. On the two northerly sections, Sturtevant blowers having a capacity of 3000 to 4000 cu.ft. per min. were installed, the larger machines being purchased for use in some of the headings of Contract 65 where the electric drills were to be tried; on the other two sections, Root blowers of 1200 to 2500 cu.ft. per min. capacity were adopted. From the blowers 10- to 16-in. galvanized pipes were carried down the shafts and 10- to 12-in. pipes into the tunnels as close to the headings as practicable.

For the transportation of men and materials between the tunnels and the surface, two 5x8-ft. balanced cages were installed in each shaft and operated by 90- to 150-hp. motor-driven single-drum hoists, of Lidgerwood, Lambert and Flory types, capable of moving the cages at a maximum speed of 400 ft. per min. On two sections these cages were self-dumping, a satisfactory type where the tunnel muck may be dumped into bins at the shaft head. Devices to prevent overwinding were placed on all hoists. Electric traction was generally adopted in the tunnel. On the northerly section, however, mules hauled the tunnel spoil in cars of 1 cu.yd. capacity, the trolley tractors being deferred until concreting began, in the belief that the amount of work to be done during excavation did not warrant the greater expense of electric equipment. Electric traction was used, however, both for excavation and concreting on the other three sections; on Contract 65, 3- to 5-ton trolley tractors hauling muck cars carrying 2 cu.yd. and on Contracts 66 and 67, 4-ton General Electric storage-battery tractors hauling muck cars of 1⅓ cu.yd. capacity were employed. Greater speed could be made with the trolley tractors and the latter gave continuous service with little interruption for repairs, but the storage-battery tractor had many advantages, notably in doing away with the dangerous trolley wire, and in avoiding the expense of bonding the tracks.

The City Tunnel was largely excavated by the well

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tried top-heading and bench method common in this country. A few hundred feet of tunnel were taken out, however, by the bottom-heading method, but this method did not prove as advantageous as the top-heading method and was quickly abandoned. The relative position of the working faces in the top-heading method and a typical arrangement of the drill holes are shown in the sections of Fig. 8. Generally the bench was excavated within 50 to 75 ft. of the heading, as here shown, and the drilling at each face carried on independently. The headings were drilled from 2 to 3 columns, the bench holes with tripod drills and the muck from the headings wheeled in barrows over the bench to plank runs over the muck cars. It was the practice at several shafts, notably in the smaller tunnels where the bench was low, and particularly at two shafts where a mucking machine was employed, to keep the bench close to the heading and drill the bench holes from the shaft columns.

With the length and arrangement of holes indicated in Fig. 8, i.e., 10-ft. holes in the cut and 8-ft. holes in the other rounds, an advance of 5 to 6 ft. was made in the heading when working in the direction of the strike of the rock. The cut holes seldom pulled to the bottom. Much longer rounds with cut holes 12 ft. or more in depth were drilled at several shafts, where one long advance per day was attempted. Except as special conditions existed, restricting, for example, the blasting to certain hours of the day, little was probably gained by such long rounds, inasmuch as the cut holes did not pull readily and sometimes had to be reloaded two or three times. The holes of the several heading rounds were frequently all loaded at once before shooting, but it was considered better practice to load each round separately as it was shot. The bench rounds were all loaded at once with the cut. Fuse firing was attempted in one instance for a few weeks, but No. 8 double-strength blasting caps

TABLE IV. CAPACITY OF COMPRESSOR PLANTS AND NUMBER OF DRILLS OPERATED

Contract	Shaft	Prime Mover	Number and Type of Compressors	Nominal Capacity of Plant. Cu.Ft. of Free Air per Min. Compressed to 100 Lb. per Sq.In.	Number of Drills of Given Type Set Up Simultaneously in the Tunnels	Adequacy of Compressor Plant
63	1–5*	2 Keeler and 4 Heine water-tube boilers, 1600-hp.	2 Sullivan tandem-compound, two-stage, 2500 c.f.p.m., Type WC 2 Ingersoll-Rand cross-compound, two-stage, 2500 c.f.p.m., Class OC3	10,000	8 Sullivan 3½″ 7 Ingersoll-Rand 3½″ 20 Ingersoll-Rand 3½″ 5 Jap	Ample, even with large use for ventilation
65	6	2 General Electric, 6600-volt a.-c. motors	2 Ingersoll-Rand			
		1 200-hp.	1 1050 c.f.p.m.; Imperial Type 10 BD	1,600	†† 5 Ingersoll-Rand 3½″	Sufficient
		1 100-hp.	1 550 c.f.p.m.; Imperial Type 10 BD		6 Ingersoll-Rand 3¼″	
	7	3 General Electric, 6600-volt a.-c. motors	2 Ingersoll-Rand and 1 Sullivan			
		2 200-hp.	1 1150 Ingersoll-Rand c.f.p.m.; Imperial Type 10 BD 1 900 Ingersoll-Rand c.f.p.m.; Class NE1	2,300	** 9 Ingersoll-Rand 3½″	Surplus
		1 60-hp.	1 250 Sullivan c.f.p.m.; Class WJ4			
	8	2 General Electric, 6600-volt a.-c. motors	2 Chicago Tool Co.			
		1 200-hp.	1 1050 c.f.p.m.; Type CBG	1,600	‡ 7 Ingersoll-Rand 3½″	Surplus
		1 100-hp.	1 550 c.f.p.m.; Type MCB			
	9	3 General Electric 6600-volt a.-c. motors	2 Chicago Tool Co. and 1 Sullivan			1850 c.f.p.m. ample, but 1600 c.f.p.m. found insufficient
		1 200-hp.	1 1050 Chicago Tool Co. c.f.p.m.; Type CBG	1,850	14 Ingersoll-Rand 3¼″ and 3½″	
		1 100-hp.	1 550 Chicago Tool Co. c.f.p.m.; Type MCB			
		1 60-hp.	1 250 Sullivan c.f.p.m.; Type WJ4			
	10	2 General Electric 6600-volt a.-c. motors		1,600	14 Ingersoll-Rand	Barely enough. Insufficient for additional drills
		1 200-hp.	1 Sullivan 1050 c.f.p.m.; Type WJ			
		1 100-hp.	1 Ingersoll-Rand 550 c.f.p.m.; Imperial Type LOBD			
	11	2 General Electric 6600-volt a.-c. motors	2 Sullivan	1,600	14 Ingersoll-Rand 3½″	Insufficient
		1 200-hp.	1 1050; Type WJ			
		1 100-hp.	1 550; Type WJ			
	12	3 General Electric 6600-volt a.-c. motors	2 Ingersoll-Rand and 1 Sullivan			
		1 200-hp.	1 Ingersoll-Rand 1050; Type XB2			
		1 100-hp.	1 250 Ingersoll-Rand; Type NE1	1,550	**10 Ingersoll-Rand 3½″	Occasional shortage
		1 50-hp.	1 Sullivan 250; Type WJ4			
66	13–14–15*	3 Westinghouse 400-hp., 6600-volt a.-c. motors	3 Sullivan cross-compound 2100 c.f.p.m.; Type Wn2	13–2,100 14–2,100 15–2,100	12 Sullivan 3½″ 12 Sullivan 3½″ 12 Sullivan 3½″	Ample
	16	1 Crocker-Wheeler 360-hp., 6600-volt a.-c. motor	1 Ingersoll-Rand, two-stage, direct-connected; Type PE	2,100	‡6 Ingersoll-Rand 3½″	Surplus
	17	1 Crocker-Wheeler 360-hp. 6600-volt a.-c. motor	1 Ingersoll-Rand, two-stage, direct-connected; Type PE	2,100	12 Ingersoll-Rand 3½″	Ample
	18	1 Crocker-Wheeler 360-hp., 6600-volt a.-c. motor	1 Ingersoll-Rand, two-stage, direct-connected; Type PE	2,100	12 Ingersoll-Rand 3½″	Ample for 12 drills; insufficient for 14
67	19	2 General Electric 6600-volt a.-c. motors	2 Ingersoll-Rand, two-stage; Type PE			
		1 215-hp.	1 1300 c.f.p.m.	2,200	‡ 6 Ingersoll-Rand 3½″ and 3¼″	Surplus
		1 164-hp.	1 900 c.f.p.m.			
	20	2 General Electric 6600-volt a.-c. motors	2 Ingersoll-Rand, two-stage; Type PE			
		1 215-hp.	1 1300 c.f.p.m.	2,200	12 Ingersoll-Rand 3½″ and 3¼″	Occasional shortage of air
		1 164-hp.	1 900 c.f.p.m.			
	21	2 General Electric 6600-volt a.-c. motors	2 Ingersoll-Rand, two-stage; Type PE			
		1 215-hp.	1 1300 c.f.p.m.	2,200	‡ 6 Ingersoll-Rand 3½″ and 3¼″	Surplus
		1 164-hp.	1 900 c.f.p.m.			
	22	2 General Electric 6600-volt a.-c. motors	2 Ingersoll-Rand, two-stage; Type PE			
		1 215-hp.	1 1300 c.f.p.m.	2,200	12 Ingersoll-Rand 3½″ and 3¼″	Ample
		1 164-hp.	1 900 c.f.p.m.			
	23†	1 General Electric 6600-volt a.-c. motor 164-hp.	1 Ingersoll-Rand, two-stage; Type PE 900 c.f.p.m.	900	‡ 6 Ingersoll-Rand 3½″ and 3¼″	Sometimes insufficient air
	24†	1 General Electric 6600-volt a.-c. motor 164-hp.	1 Ingersoll-Rand, two-stage; Type PE 900 c.f.p.m.	900	‡ 6 Ingersoll-Rand 3½″ and 3¼″	Ample

* Central plant for these shafts. Later each compressor at plant for Shafts 13, 14 and 15 was piped separately. † One heading only at this shaft.
** Only one heading running full. †† Bench drilled from heading columns. ‡ Drilling in one heading only.

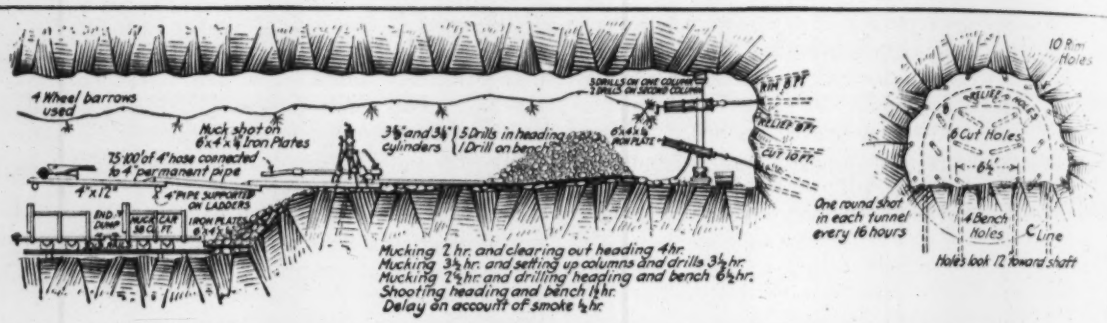

4 Wheel barrows used
Muck shot on 6'x4'x¼ Iron Plates
75-100' of 4" hose connected to 4" permanent pipe
4"x12"
4" PIPE SUPPORTED ON LADDERS
END DUMP
MUCK CAR 50 CU. FT.
IRON PLATES 6'x4'x¼
3½" and 3¼" cylinders
5 Drills in heading
1 Drill on bench
5 DRILLS ON ONE COLUMN
2 DRILLS ON SECOND COLUMN
6'x4'x¼ IRON PLATE
RELIEF 8 Ft.
CUT 10 Ft.
Mucking 2 hr. and clearing out heading 4 hr.
Mucking 3½ hr. and setting up columns and drills 3½ hr.
Mucking 2½ hr. and drilling heading and bench 6½ hr.
Shooting heading and bench 1½ hr.
Delay on account of smoke ½ hr.
10 Rim Holes
6 Cut Holes
6½'
One round shot in each tunnel every 16 hours
4 Bench Holes
C Line
Holes look 12° toward shaft

FIG. 8 - TYPICAL ARRANGEMENT OF DRILL HOLES IN CITY TUNNEL, CATSKILL AQUEDUCT

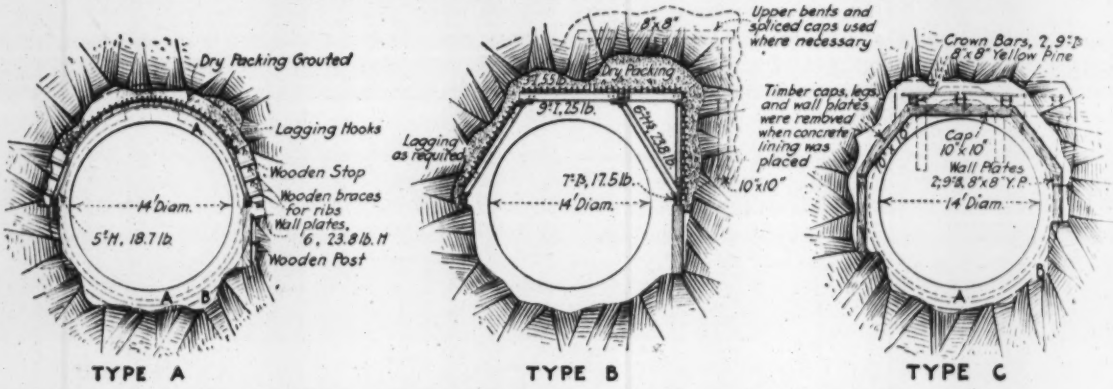


FIG. 9 - TYPES OF ROOF SUPPORT, CITY TUNNEL, CATSKILL AQUEDUCT

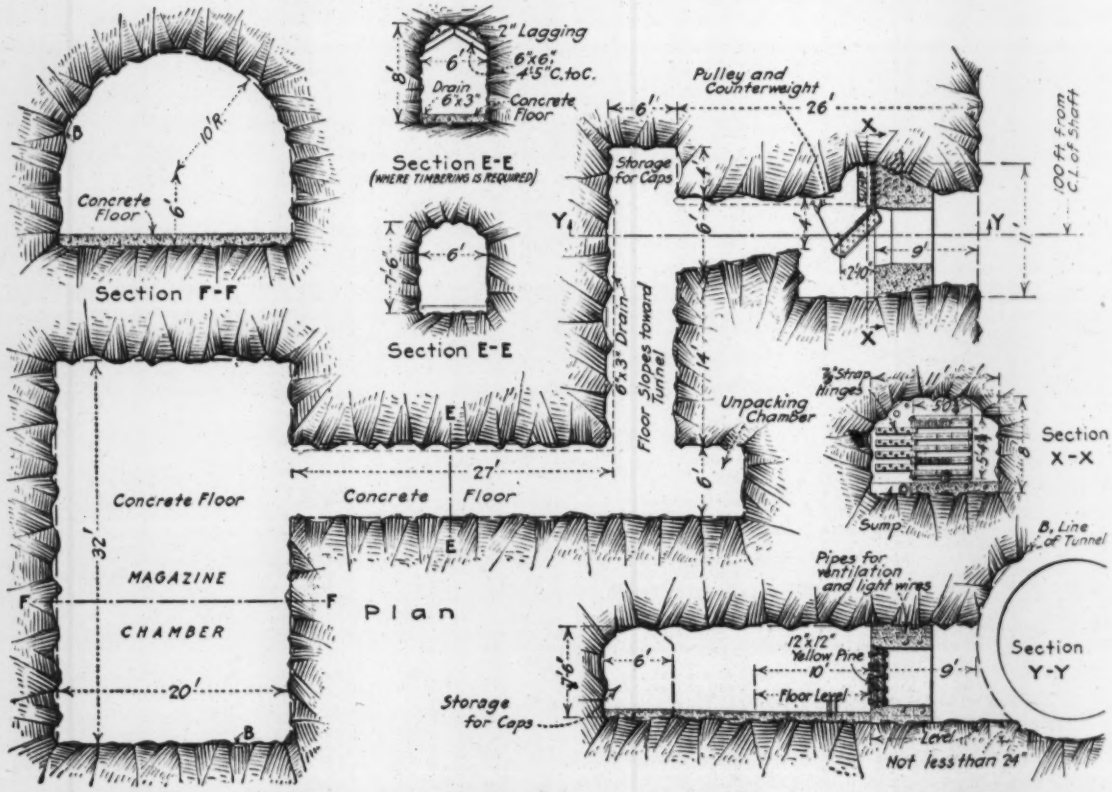


FIG. K) - DETAILS OF MAGAZINES FOR HIGH EXPLOSIVES, CITY TUNNEL, CATSKILL AQUEDUCT

DRILL HOLES, ROOF SUPPORTS AND MAGAZINES FOR HIGH EXPLOSIVES

or electric detonators connected in series were otherwise universally used. These were exploded through a connection with the lighting circuit of 110- and 220-volt alternating current. All but one bench round were fired first, the last bench round with the heading cut. The amount of 60% "Forcite" and low-freezing gelatin of the same strength used per cubic yard of excavation in the City Tunnel is given in Table V. The average on the whole tunnel was 4.8 lb. The smaller amount of explosives used on Contract 63 was due to the favorable size of the tunnel, and to the efforts of the contractor in the direction of economy by more carefully placing and loading the holes.

The driving of the tunnel was organized in two ways: one, by the separate method on the basis of four to six shifts of drillers and muckers, half working independently in each heading, by which two advances were made daily in each heading, and the other, the continuous method on the basis of three shifts of drillers and muckers alternating between the two headings, by which two or three advances were made daily in two headings. Comparing the tunnels of equal size driven in the same formations, it appeared that a little more progress was made per man employed under the continuous method, or the three-shift organization. No time was lost by this method as the tunnel force went into the other heading as soon as it completed its task in one, and this method had the added advantage of giving ample opportunity to clear the smoke from a heading after shooting before work was resumed. On the other hand, more daily progress was made by the separate method, and against a slight economy in labor effected by the continuous method must be charged the saving on plant and overhead charges made by the separate or four-shift method, by sooner completing the work. Where, as on the City Tunnel, a large percentage of the payments is retained until the work

TABLE V. PROGRESS IN DRIVING CITY TUNNEL

Contract, Sec.	Shaft	Fin. Diam. of Tunnel, Ft. North	Fin. Diam. of Tunnel, Ft. South	Amount of Excavation within Payment Lines, Cu.Yd. per Lin. Ft. of Tunnel North	Amount of Excavation within Payment Lines, Cu.Yd. per Lin. Ft. of Tunnel South	Ft. of Tunnel Driven from This Shaft, Exclusive of Width of Shafts North	Ft. of Tunnel Driven from This Shaft, Exclusive of Width of Shafts South	Rock Formation	Organization Generally Employed; Number of Shifts in both Headings Drillers	Organization Generally Employed; Number of Shifts in both Headings Muckers	Time Lost from Driving in Changing from Shaft Sinking to Tunnel Driving Plant, Days	Months Driving Headings before Met, Exclusive of Delays Due to Changing over Plant for Tunnel North	Months Driving Headings before Met, Exclusive of Delays Due to Changing over Plant for Tunnel South	Average Monthly Progress in Each Heading, Ft.	Average Amt. of Explosive Used at Each Shaft per Cu.Yd. (A)
63	1	15	..	10.40	.....	1894	....	Yonkers gneiss	3	3	19	12½	...	152	3.7
			15	.....	10.49	....	1276	Yonkers gneiss	..	..	..	....	12½	102x	
	2	15	..	10.49	.....	2196	....	Yonkers gneiss	3	3	17	13½	...	163	3.5
			15	.....	10.49	.....	2061	Yonkers and Fordham gneiss	..	..	..	....	15	137x	
	3	15	..	10.49	.....	1703	....	Yonkers and Fordham gneiss	3	3	15	17	...	100x	4.3
			15	.....	10.49	....	2746	Fordham gneiss	..	..	..	....	17	161	
	4	15	..	10.49	.....	2220	....	Fordham gneiss	3	3	14	16 .	...	139	4.4
			15	.....	10.49	....	2320	Fordham gneiss	..	..	..	....	17½	136	
	5	15	..	10.49	.....	2534	....	Fordham gneiss	3	3	12	15½	...	161	4.3
			15	.....	10.49	....	2204	Fordham gneiss	..	..	..	....	14½	153	
Total						21,154									
Average											15	...	...	140	4.1
65	6	15	..	10.49	.....	2212‡	....	Fordham gneiss	4	4	18	16½	...	123x	4.0
			15	.....	10.49	....	2740	Fordham gneiss	..	..	..	....	17½	154	
	7	15	..	10.49	.....	2302	....	Fordham gneiss	2 to 3	2 to 6	25	14½	...	156	4.3
			15	.....	10.49	....	1058	Inwood limestone	..	..	..	....	7	151	
	8	15	..	10.49	.....	1437	....	Manhattan schist	3	3	19	9½	...	151	6.2
			15	.....	10.49	....	1615	Manhattan schist	..	..	..	....	9½	175	
	9	15	..	10.49	.....	2573	....	Manhattan schist	3 to 4	4	26	16½xx	...	145	5.5
			15	.....	10.49	....	2048	Manhattan schist	..	..	..	....	15xx	137x	
	10	15	..	10.49	.....	1594	....	Manhattan schist	3 to 4	4 to 6	28	11½S	...	136x	5.1
			14	.....	9.43	....	1914	Manhattan schist	..	..	..	....	10½S	182	
	11†	14	..	9.43	.....	2268	....	Manhattan schist	3 to 4	4	32	14½	...	154	5.3
			14	.....	9.43	....	2195	Manhattan schist	..	..	..	....	13½	160	
	12	14	..	9.43	.....	2614	....	Manhattan schist	3	3 to 4	25	15½	...	171	5.0
			14	.....	9.43	....	1643**	Manhattan schist	..	..	..	....	9½	173	
Total						28,213									
Average											25	...	...	154	5.0
66	13	14	..	9.43	.....	1642	....	Manhattan schist	4	4	6//	8½	...	187	5.0
			14	.....	9.43	....	1880	Manhattan schist	..	..	..	....	9½	198	
	14	14	..	9.43	.....	2038	....	Manhattan schist	4	4	11	10½	...	194	4.8
			14	.....	9.43	....	1661	Manhattan schist	..	..	..	....	10½	162	
	15	14	..	9.43	.....	1965	....	Manhattan schist	4	4	14	9½	...	200	5.2
			14	.....	9.43	....	2032	Manhattan schist	..	..	..	....	16½	195	
	16†	14	..	9.43	.....	2010	....	Manhattan schist	3	3	31	10½	...	192	3.8
			14	.....	9.43	....	1181	Manhattan schist	..	..	..	....	7½	162	
	17	14	..	9.43	.....	1106	....	Manhattan schist	3	3	34	7½	...	144x	4.8
			13	.....	8.42	....	1621	Manhattan schist	..	..	..	....	8½	200	
	18	13	..	8.42	.....	2918	....	Manhattan schist	4	4	5//	12	...	232	6.8
			12	.....	7.40	....	2992	Manhattan schist	..	..	..	....	13	230	
Total						23,046									
Average											17	...	...	195	5.1
67	19	12	..	7.40	.....	2222††	....	Manhattan schist	3	3	29	9½	...	236	5.2
			12	.....	7.40	....	1884	Manhattan schist	..	..	..	....	8½	217	
	20†	12	..	7.40	.....	1957	....	Schist, gneiss and Inwood limestone	4	6	25	7½	...	268	5.8
			12 & 11	.....	7.40 to 6.51	....	2974	Limestone	..	..	..	....	10	297	
	21†	11	..	6.51	.....	1259	....	Fordham gneiss and limestone	3	3	15	6½	...	207	5.5
			11	.....	6.51	....	1279	Fordham gneiss (granodiorite)	..	..	..	....	5½	232	
	22	11	..	6.51	.....	2754	....	Fordham gneiss (granodiorite)	6	6	24	10½	...	270	5.7
			11	.....	6.51	....	3059	Fordham gneiss (granodiorite)	..	..	..	....	11½	268	
	23*	11	..	6.51	.....	1971	....	Fordham gneiss (granodiorite)	3	3	12	8½	...	232x	5.7
	24*	11	...	6.51	.....	1732	....	Fordham gneiss (granodiorite)	3	3	15	7½	...	234	5.7
Total						21,091									
Average											20	...	...	250	5.6
Total city tunnel						93,504									
Average city tunnel														175	4.8

* One heading only. † Shafts on short drifts not included in length of tunnel driven.
‡ Includes 210 ft. driven from Shaft 5. Rate of driving based on 2002 ft. in 16¼ months.
xx Includes 1½ months when work suspended because of fire in head-works.
x Delayed by bad ground.
** Includes 2 ft. driven from Shaft 13.
†† Includes 26 ft. driven from Shaft 18 but not included in estimate of progress.
// Timbered shafts.
S Driving suspended to begin concreting.
(A) Until fall of 1912 when 60% "Forcite" of the du Pont de Nemours Powder Co. was generally used; after that date the low freezing gelatine of the same strength made by this company was adopted.

TABLE VI. RELATIVE DIFFICULTIES OF TUNNELING AT VARIOUS DEPTHS IN ROCK IN NEW YORK CITY

Section of Tunnel From	To	Geological Formation	Length of Section, Ft.	Approximate Depth of Sound Rock Cover above Roof of Tunnel, Ft. Min.	Max.	Av.	Depth of Invert of Tunnel, Ft. below Sea Level From	To	Estimated Maximum Amount of Water Total Gal. per Min.	Av. per Mile of Tunnel, Gal. per Min.	Ft. of Roof Support	Per C... Sec... Supp...
City Line	1240′ North of Shaft 3	Yonkers gneiss	7,935	187	230	210	40	72	145	97	551	6 9
1240′ North of Shaft 3	2509′ South of Shaft 6	Fordham gneiss	18,063	150	260	195	72	143	587	172	2659	14 7
2509′ South of Shaft 6	25′ South of Shaft 7	Fordham gneiss	2,576*	270	430	310	143	331	0	0	0	0
25′ South of Shaft 7	965′ South of Shaft 7	Inwood limestone	940	180	300	230	331	331	155‡	861	0	0
965′ South of Shaft 7	550′ South of Shaft 11	Manhattan schist	14,154	160	480	370	331	365	79	29	880	6 2
550′ South of Shaft 11	2561′ South of Shaft 11	Manhattan schist	2,011*	250	320	285	357	176	1	3	113	5 6
2561′ South of Shaft 11	Shaft 19†	Manhattan schist	29,278	150	280	185	143	181	169	30	1870	6 4
Shaft 19†	1165′ North of Shaft 20	Manhattan schist	2,685	600	630	610	664	682	13	25	43	1 6
1165′ North of Shaft 20	535′ North of Shaft 20	Inwood limestone	630	400	620	590	682	693	0	0	0	0
535′ North of Shaft 20	85′ North of Shaft 20	Fordham gneiss	450	400	590	510	693	700	0	0	0	0
85′ North of Shaft 20	1400′ South of Shaft 20	Limestone	1,485	400	620	470	700	700	0	0	20	1 3
1400′ South of Shaft 20	200′ North of Shaft 21	Interbedded Fordham and limestone	2,633	160	640	450	700	704	0	0	39	1 5
200′ North of Shaft 21	Shaft 22†	Granodiorite of Fordham gneiss series	4,242	550	640	600	704	662	17	21	11	0 3
Shaft 22†	Shafts 23 and 24	Granodiorite of Fordham gneiss series	6,806	150	210	190	288	269	1270**	984	468	6 9
Total			93,888						2436		6654	
Average										137		7 1

*Incline 9 per cent. grade ‡ Under Harlem River. ** Nearly half of this in section 100 ft. long near Shaft 23. † Step shaft. Rocks encountered in order of hardness, Inwood and other limestones, Manhattan schist, Fordham gneiss, Yonkers gneiss, granodiorite (Brooklyn).

is finished and the contractor is under a large bond for the performance of the work, a saving in overhead expenses is not a factor to be neglected.

Compared with other tunnels of the Catskill Aqueduct, no remarkable progress was made in driving the City Tunnel, largely because the rock was fairly hard and was generally excavated along the strike of the formations, and because the conditions in the city under which the work had to be done were not favorable to rapid work. In several sections, the excavation was carried on at a uniform rate in advance of contract requirements, which reflected great credit on those in charge. The best progress was made in the limestone at Shaft 20, where 105 ft. were excavated in one heading in a week, and at Shaft 22, where 198 ft. in the granodiorite were excavated in two headings in the same time. For a period of a month, the best record in one heading was 371 ft., and in two headings 652 ft., both at Shaft 20, but the average monthly progress in limestone of the south heading at this shaft where the fastest schedule was maintained, was only 297 ft., and the average in one heading for the entire tunnel was but 175 ft. per month. The progress in driving the City Tunnel is summarized in Table V.

With regard to the factors which affected progress and economy in driving the City Tunnel—the amount of water encountered, the condition of the rock requiring roof support, the speed of drilling and the amount of explosives required—the best tunneling rocks were the Manhattan schist, through which 9.1 miles of the tunnel was driven, and the much softer limestone of the Inwood and Fordham series, in which 0.6 mile of the tunnel was excavated. At equal depths the older and harder rocks of the Yonkers and Fordham gneiss formations in the Bronx and Brooklyn were less favorable. The maximum amount of water found in the several sections of the tunnel and the amount of roof support erected are shown in Table VI. This brings out the fact that, where the rock cover was considerable, all formations afforded good tunneling ground, little water being found and little roof support being required. The phenomenon of popping rock, noted previously in the Hudson River siphon (ENGINEERING NEWS, Mar. 23, 1911), was only observed in the city below 500 ft. in the shafts and tunnels on the lower east side.

A greater part of the roof support was of the permanent steel type, shown in Fig. 9, either the standard curved ribs of H-beams, Type A, or the special three-piece bents of I-beams, Type C, supported on steel wall plates. Of the 6378 ft. of supported tunnel, only 1982 ft. of tunnel were supported by temporary timber, and most of this was in the schist. This timber was set up in three-piece bents, of 10x10-in. sticks either carried in hitches or supported on timber plates and plumb posts. Temporary timber was ordinarily used in ground that was not particularly heavy; in other words, it had its proper use in ground which was not sufficiently bad to warrant the greater expense of permanent steel support, yet which appeared unsafe to leave altogether unsupported. The disadvantage of temporary timber support was that it had to be removed before the concrete lining was placed. This operation was always somewhat hazardous and there was the possibility in taking down the timber in bad ground that wide breakage in the roof would result. Aside from the economy of the timber and the advantage of placing the concrete directly against the rock, an advantage shared by the steel roof support if the lagging could be omitted, it was generally preferable to erect permanent steel roof support, rather than temporary timber, because the steel made the roof safe for all subsequent operations and no further yielding of the roof could occur. Furthermore, when the concrete lining was placed inside the steel and the dry packing above the support was well grouted, the result was a stronger roof than that afforded by the concrete lining without such reinforcement. Either of the types of steel support could be set up close to the face of the heading, using short lengths of wall plates, placed in small drifts in advance of the main heading, so that the men were but little exposed to falls of rock. If these steel bents were properly braced, they readily resisted the impact of the shots from the heading.

The three-piece steel bents were designed for heavy concentrated loads, while the curved-rib type was better

adapted to a condition of uniform loading on the arch. The latter type gave remarkably good account of itself, however, and failed in but one instance under a movement of rock just above the springing line. It should be noted that the lagging and dry packing were not always placed over the entire length of the rib, but were omitted over that portion of the roof not requiring close support and the ribs there braced against the roof by blocking to prevent distortion under the eccentric loading.

An interesting type of support made up of longitudinal steel crown bars, supported on temporary timber or permanent steel bents, is shown as Type C in Fig. 9. This was used to carry a section of blocky roof between Shafts 16 and 17 and afforded excellent protection to the men working on the bench. The crown bars were carried close to the heading and exposed only their ends to rock shot out of the heading. Support for these bars at the working face was provided by temporary timber horse heads.

Notable among safety measures taken by the engineers were the frequent examination and testing of the cages and equipment, the supervision of the loading and drilling of the headings and the efforts made to prevent any accidents in the storage and handling of explosives. Perhaps the most important of these measures was the adoption, with the consent of the municipal authorities, of the underground magazine shown by Fig. 10. This magazine was excavated in the solid rock at the end of a tortuous drift 75 ft. in length, driven laterally from the tunnel at a point distant 100 ft. from the shaft. A heavy door made up of 12x12-in. timbers and 15-in. I-beams was hung in a concrete bulkhead at such an angle as to quickly close in the event of an explosion in the magazine.

With the exception of the four northerly shafts in undeveloped portions of the city, where surface magazines were permissible, and could be placed some distance away from the shafts, and one shaft at the East River, where a surface magazine could be safely located on the bulkhead, an underground magazine of this design was constructed at each shaft and the storage of dynamite not exceeding 1000 lb. permitted. These magazines have now all been discontinued, and it is gratifying to realize that something like 2200 tons of high explosives were handled on this work without an accident to a magazine. The great hazard to which the public would have been exposed by the storage of 1000 lb. of dynamite on the surface within the contracted spaces allotted to the contractor about the shaft heads, was demonstrated in August, 1913, by the fire which burned down the headworks of Shaft 9 at St. Nicholas Ave. and 149th St. The flames swept through the buildings within the contractor's inclosure so rapidly that the workmen there escaped with difficulty and did not succeed in saving even their personal effects. They would not have had time to empty a surface magazine.

Costs

The cost of driving the tunnels, including excavation, roof support, drainage, pumping, etc., based on the contractor's bid prices, was as follows:

Finished Diameter of Tunnel, Ft.	Approximate Average Cost per Ft. of Driving Tunnel on Several Contracts
15	$90
14	96
13	97
12	89
11	86

The Broad St. Wood Block Pavement, Newark, N. J.

To the readers of the editorial and correspondence on the means of preventing "blow-ups" in wood block pavements, in ENGINEERING NEWS, May 14 and June 4, 1914, the paving of Broad St., Newark, N. J., is of particular interest, for it was on this work that the specifications required the blocks to be immersed in water before laying. Various opinions on the efficiency and expediency of this treatment were expressed by correspondents in our issue of June 4, and subsequently. This pavement was completed Oct. 1, 1914, and the following description of the work is taken from a paper read by William A. Howell, Engineer of Streets and Highways of Newark, at the recent Chicago Road Congress.

In regard to the much discussed soaking of the blocks before laying, Mr. Howell says:

> This method of thoroughly soaking the blocks for ten minutes before laying them in the pavement is new in this country, and has been criticized on account of the expense involved in maintaining so large a number of tubs and the men necessary to handle them properly. The results so far obtained seem to justify the method, and it will undoubtedly be a feature in any future wood block contracts entered into by the city of Newark.

The specifications further provided against expansion as follows:

> (1) By providing for expansion joints along the curbs, 1½ in. wide to be filled with a suitable bituminous filler capable of passing a good penetration test.
>
> (2) By laying the blocks comparatively loose in the pavement, in order not to have any tight joints, sand being carefully broomed into the joints.

More than the usual precautions against expansion were necessary, because the street is very wide—132 ft. between building lines, 92 ft. from curb to curb, and 38½ ft. from street-car rail to curb.

The street-railway track was responsible for the only trouble experienced. The movement of the rail under load raised a few blocks in some places, but this happened in less than a dozen spots in 10,000 lin.ft. of pavement. After the necessary repairs to the track and the relaying of the blocks, no difficulty was experienced.

Bleeding was extremely noticeable on several very warm days, but the covering of the pavement with a thin coating of sand obviated all nuisance from this cause. During the summer and fall the pavement was sprinkled quite frequently.

Early in the fall a thick coating or crust formed on top of the blocks, caused by the oozing out of the preservative and its coming in contact with the sand. The contractor scraped this off and removed it from the street on several occasions.

Two sizes of blocks were used, from different plants, and treated with two different preservative oils, which varied much in character. One part of the pavement is laid with 4x4x8-in. blocks, and the other with 3x4x8-in. blocks, both of good quality southern long-leaf yellow pine. The oils varied much from one another in naphthalene compounds (the fractions between 210° and 235° C.); in one test one oil had four times as much as the other oil.

Both orders of blocks received careful inspection when manufactured and were laid under identically the same inspection in the street and by the same contractor, so that the comparative results which may occur as regards bleeding and buckling will be of particular interest.

The First Large American Humphrey Pump

By C. C. Trump*

The plant arrangements of the first American installation of a large Humphrey direct-acting explosion pump were given in Engineering News, Oct. 15, 1914; to those general notes, the writer would here add the details of the pump itself. It is sufficient, perhaps, briefly to recall that at Del Rio, Texas, a single 66-in. pump is being installed of 28,000 gal. per min. capacity against 37-ft. head, the service being for irrigation on the G. Bedell Moore Estate. Mesquite wood will be burned in an Akerlund bituminous-fuel producer until the land is cleared.

The design of this American pump differs from the English prototype (see Engineering News, Dec. 2, 1909, p. 603; Apr. 17, 1913, p. 764; Dec. 25, 1913, p. 1331) in several important details. The requirements of American pumping-engine practice, as well as the experience with the Humphrey pump abroad, have made it advisable to simplify the construction in every possible way. Further, the opportunity to standardize the working parts to fit a line of pumps of different sizes has been seized, and wherever possible, as especially in the case of the water valves, that type of construction has been adopted which has stood the test in long years of actual service. The aim has been to combine high economy with the American prerequisites of simplicity, reliability, durability and low cost of maintenance.

*The Humphrey Gas Pump Co., Syracuse, N. Y.

The combination of explosion cylinder, valves and play pipe which forms the pump (Fig. 1) takes the shape of a short-legged V, the play pipe extending up the bank of the Rio Grande at 45° from a two-part 135° bend upon which the water valves and power cylinder are set. The upper end of the play pipe is held in a reinforced-concrete surge tank, while the lower end and bend is embedded in the bottom of the concrete pump well.

The major parts of the unit are of steel; the straight parts of play pipe and cylinder are of plate with welded or riveted joints. The more intricate parts, such as cylinder head, belt for gas valves, box for water intake valves, and the two bends are unusually large steel castings. For smaller parts, such as valve cages, a special cast iron, known as "semi-steel," is used simply for convenience and time-saving in manufacture. Working parts subject to corrosion from actual contact with water, such as valves and their seats, are made from manganese bronze.

Play Pipe—The delivery, having a total length in its straight part of 73½ ft., is made in three parts for convenience of transportation and economical distribution of metal. The two rings farthest from the power cylinder, where the pressures are low, are made of $\frac{5}{16}$-in. plate, with a tensile strength of 60,000 lb. per sq.in. The other eight rings are each thicker than the one before by $\frac{1}{16}$ in. until the one nearest the bend has a thickness of $\frac{7}{8}$ in.

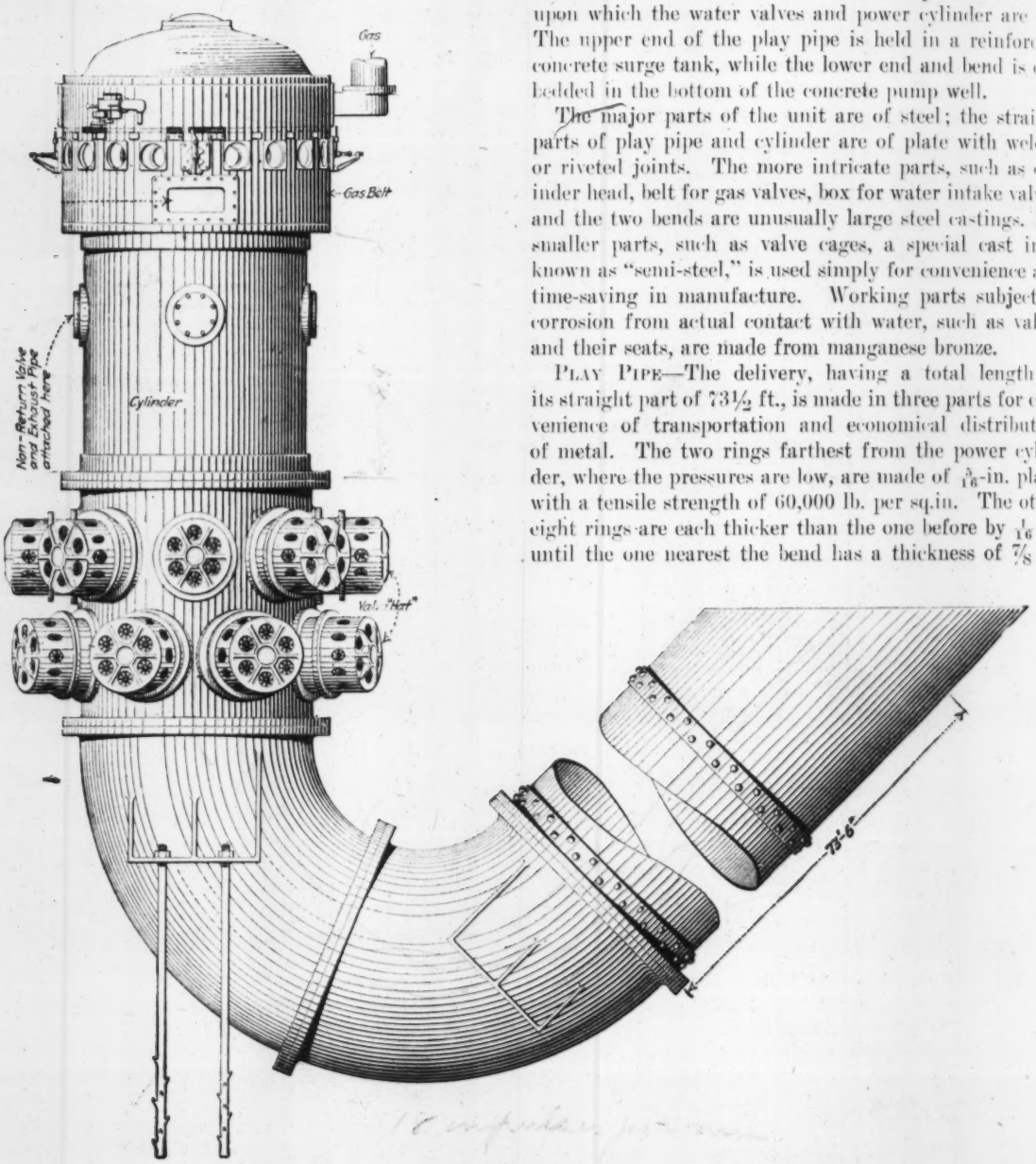


Fig. 1. Elevation of the 66-In. Humphrey Pump for Del Rio, Texas

All the seams are riveted butt joints with outside straps and heads countersunk inside the pipe.

Bend—The 135° bend between play pipe and cylinder (Fig. 1), for convenience in handling and transportation, is made of two steel castings bolted together. The two 67.5° parts are identical except that the tenons are reversed. Even the foundation brackets remain in the same position on the pattern, those on the upper part serving to support the water-intake valves and cylinder when the pump is set on the foundations, while those on the

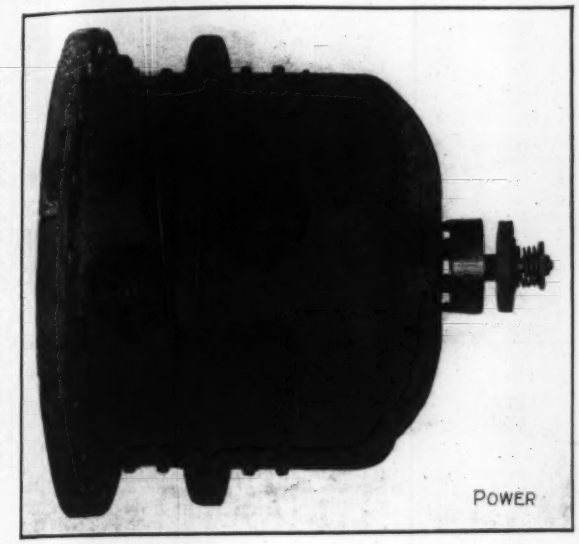


Fig. 2. Water Valve Hat-Unit Construction

lower part (reversed) are in proper position to take the thrust of the column of water in the play pipe.

Water Valves—Immediately on top of the bend is set the box for water-intake valves with its "hat"-unit construction, as shown in Fig. 2. The box itself is a steel casting weighing some 13,000 lb. It has openings for 16 "hats," or cages, containing 25 valves each, or a total of 400 for the pump. The valve cages are "semi-steel" castings into which the valve seats of manganese bronze are forced with a taper fit of 1 in. to the foot. The box is no heavier than the corresponding valve chambers of any pumping engine of equal capacity, and it gives a good impression of the real immensity of the machine.

The water valves themselves are of a standard type, according to the Freeman specifications of the Associated Factory Mutual Fire Insurance Companies.

This valve differs from the standard Underwriters' valve in that it is 5 in. in diameter, the largest standard valve being 4 in. The larger valve is permissible in view of the slower speed and more gradual closing of the water valves. The use of the plain rubber or fiber disk, rigid center stem, large spring and self-retained guard makes it a most reliable and convenient valve. The retaining nut of brass is held in place by a hexagonal socket in the guard under spring pressure, but may be removed with the fingers of one hand whenever it becomes necessary to renew the valve disk. The valve disks on the Del Rio pump, because of sand in the river water, will be of a composition which has given satisfaction in water-works service under similar conditions. Every feature of the entire water-valve construction has been thoroughly tested in long years of service on all kinds of pumping engines; also its adaptability to the Humphrey pump has been proved by experiments during three years' actual operation.

Power Cylinder—The cylinder, which is placed just above the water-valve box, forms part of the combustion chamber. It is, in this case, a piece of riveted pipe, 66 in. inside diameter and 89 in. long. The plate is $\frac{15}{16}$ in. thick with triple-riveted butt-strap joints inside and out. The rivets are $1\frac{3}{16}$ in. in diameter with the heads inside the pipe countersunk. The flanges are of cast steel riveted on, drilled for forty-four $2\frac{1}{4}$-in. bolts.

Supply and Exhaust Valves—The belt for gas valves, shown in Figs. 1 and 3, carries the important working parts of the pumping engine. The belt itself is a steel casting weighing about 7500 lb. It forms a double-walled section of the 66-in. cylinder, through which openings are provided for valves for the inlet of gas and air mixtures and the exhaust of products of combustion. These openings are 20 in number, all at one level; 12 are for exhaust and eight for mixture valves. In order to have an even distribution of flow of gases into and out of the cylinder, these openings are arranged in groups of two for mixture and three for exhaust, separated by a dividing wall which runs over exhaust valves and under mixture valves, around the annular space between the outer and inner walls of the belt itself. Thus the belt is divided into an upper chamber provided with a rectangular opening, to which the gas pipe is connected, and a lower chamber with two larger similar openings faced and studded for attaching two nonreturn valves and the exhaust pipes. The exhaust gases are led downward to allow any water carried with them to drain off. Drain pipes for this purpose are to be seen in the bottom of the nonreturn-valve casings.

The nonreturn valve, seat and casing comprise three parts. The seats are iron castings fastened to the belt openings with studs. The brass swing valves themselves

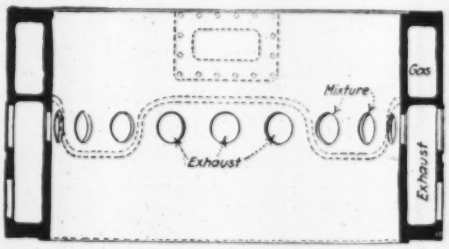
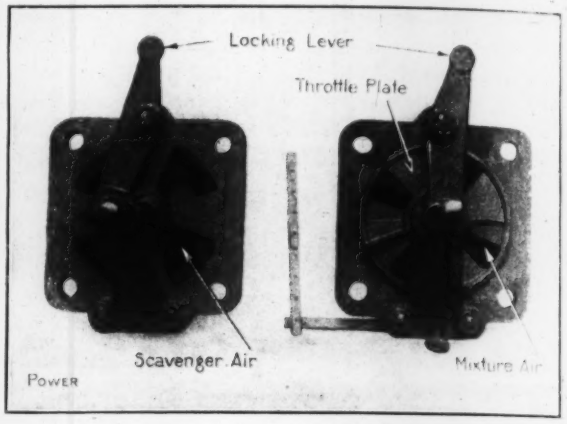


Fig. 3. Sectional Elevation of Gas-Belt Casting

are pivoted at the center and hung from hinge bolts carried in the upper corner of the casings. These are of cast iron and are bolted to the flanges of the seat castings. The exhaust pipes are led vertically upward from a round opening in the top of each nonreturn-valve casing.

Each mixture-valve cage is assembled as a unit (see Figs. 4, 5 and 6). It comprises a double, flat-faced bronze valve of the mushroom type with a 1-in. tubular stem expanded into the valve-head casting and fastened with a driven taper plug. The tubular stem is recognized construction for large air compressors where the valves work horizontally, and is light and durable. The outer end of the valve stem is threaded inside for a locking nut or head, which is fastened by an expanding bolt acting inside the quarter-threaded projection. The seat on which the valve works is also double faced, two con-

centric openings being provided of equivalent area. The inner one is for air drawn from the atmosphere directly through the cage cover around the valve stem. The outer one takes gas directly from the upper chamber of the belt. This arrangement keeps any tar or other impurities which may be carried in the gas as far as possible away from the moving stem. The seat casting is of bronze and fits into the opening through the inner wall of the gas-valve belt, while it is carried in a cast-iron cage which is bolted into the corresponding openings in the outer wall.



FIGS. 4 AND 5. TWO VIEWS OF ASSEMBLED MIXTURE AND EXHAUST VALVES

Four studs through the corners of the cage cover serve to hold the entire mixture-valve unit in place and allow its removal without disturbing any connections whatever. On this cover (Fig. 5) is carried the locking lever, hung on a pivot stud, set at such an angle as to allow the hooked end to wedge under the stem head and lock the valve tight. This feature alone on a small pump was found to reduce the gas consumption by several per cent. These locking levers are so shaped that they hang in position to lock the valve and no spring is required. Their upper end is button-shaped to engage with a lug on the interlocking chain which displaces them to unlock the valve. The spring which closes the mixture valve is of close-wound tension helical form and is adjustable by means of a screw held in a cast-iron bracket bolted to the cage at its lower edge. This bracket also retains a throttle plate with pie-shaped openings corresponding to those in the cage cover, whereby the supply of air to be mixed with the gas may be controlled. A setscrew through the spring bracket to hold the adjustment when once made completes the unit.

Paper, copper or asbestos packings can be used under the inner joint of the valve seat with the cylinder wall. The outer joint is made under the cage cover by a round packing of gutta percha or rubber squeezed into a corner by a conical bevel so that the endwise distances need not be too exact.

The exhaust-valve cage unit is interchangeable with that for mixture and differs from it in only a few details. The valve is of the same mushroom shape as the mixture valve, except in having only one flat face at its outer circumference. This makes it lighter in weight, which is of special advantage since the exhaust valve is closed suddenly by the rising water in the cylinder. The valve also is opened by the outside spring and much depends upon getting it open immediately at the end of the expansion to atmospheric pressure to secure a full volume of scavenging air by the subsequent suction. This air is drawn in through the exhaust-valve cage directly. A spring-closed scavenging valve which has its seat against the inside of the exhaust-cage cover prevents the products of combustion from escaping into the air, and the nonreturn valves between the belt and exhaust line keep the exhausted gases from returning into the cylinder instead of the fresh air.

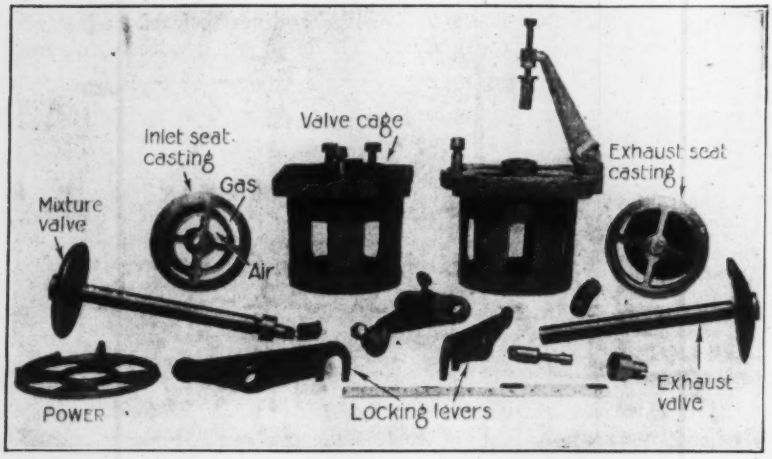


FIG. 6. PARTS OF MIXTURE AND EXHAUST VALVES

The exhaust seat is a bronze casting similar to that for the mixture valve, but without the concentric walls necessary to divide gas from air passages. The full-length stem guide is used as a rider for the scavenge valve and the four ribs hold its tobin-bronze spring in place. The cast-iron cage is from the same pattern but finished for the scavenging-valve seat and not for any throttle plate. The locking lever is simply reversed in angle of pivoting and locks the valve in the opposite direction. The spring bracket is the same except for the adjusting screw which is designed to guide a larger open-coiled compression spring. Thus the unit construction of the gas valves gives

the cylinder a workmanlike appearance, and it is hardly necessary to point out the advantages of having to carry only one complete valve assembly as a spare for each kind of valve.

VALVE INTERLOCKING—Upon the interlocking mechanism depends the entire possibility of the four-stroke cycle. As will be remembered from former descriptions of the Humphrey pump, the operation, briefly, is as follows:

A charge of gas and air is exploded in the power cylinder above the water column which forms the working piston. The water is driven downward, the water valves are closed and the liquid in the whole play pipe is set in motion. Inertia of the water column permits expansion of the exploded charge to below atmospheric pressure when first the scavenging, exhaust and water valves open. A return surge of the play-pipe column follows, and near its end the exhaust valves are closed by impact of water. A second forward surge is set up by the trapped and compressed gases and, when the pressure falls below atmospheric, a fresh charge of gas and air is drawn in. Finally, this is compressed by the second return surge and exploded, whereupon the cycle repeats.

From the foregoing it is seen that it is necessary (1) to lock the mixture valves and unlock the exhaust valves during the expansion following the power stroke and (2) to lock the exhaust valves and to unlock the mixture valves during the charging stroke. This is accomplished by a sprocket roller chain stretched around the belt above the gas valves and carrying lugs which engage the locking levers of the exhaust valves in one direction and the levers of the mixture valves in the other direction. With each explosion the chain and lugs are moved against the upper ends of the exhaust-valve lock levers, but the valves do not open until the pressure is below atmospheric. On the following "cushion" the chain is moved in the opposite direction, which (1) disengages the exhaust-valve levers and allows the valves to be locked by gravity and (2) engages the mixture-valve lock levers, moving them to unlock position from the gravity lock previously assumed.

The chain is moved by two small hydraulic engines called "shifters." Each consists of a spring-loaded horizontal piston in a single-acting cylinder of 2½-in. diameter connected with the play-pipe pressures. From Figs. 8 and 10 it is seen that a spring placed between piston-rod spearhead and chain-control lever causes the spearhead to engage upper and lower studs on the chain lever, securing the reverse motions desired. The chain lever of the shifter is connected directly through a shaft and sprocket. All working parts of the shifter are of bronze.

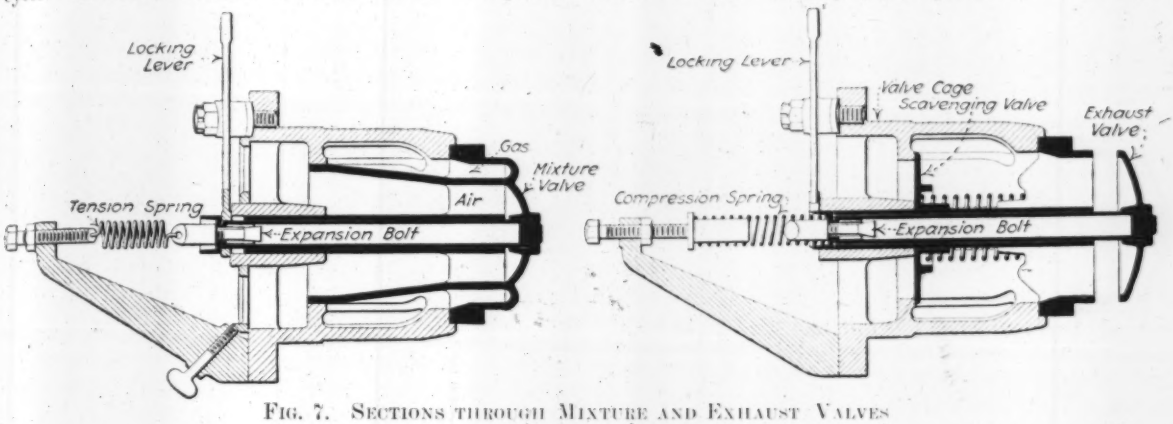


FIG. 7. SECTIONS THROUGH MIXTURE AND EXHAUST VALVES

IGNITION—The shifters also serve to actuate the "timers" or contact makers for the electrical ignition system. Contact is made only near the end of "compression" and the exact timing and duration may be varied to produce the correct effect upon combustion.

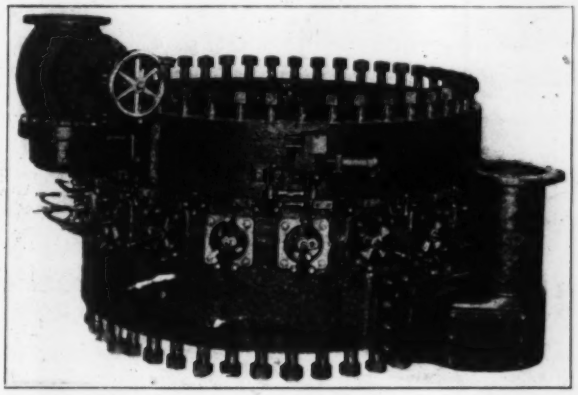


FIG. 9. ASSEMBLED GAS BELT; DEL RIO PUMP

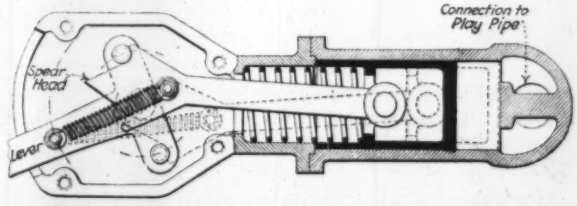


FIG. 8. SECTION THROUGH SHIFTER OF VALVE INTERLOCK

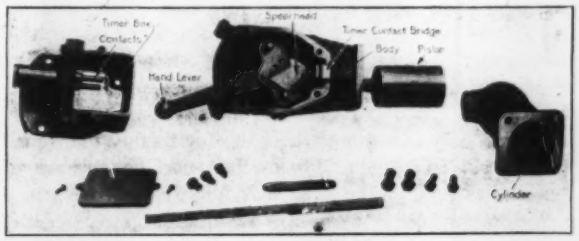


FIG. 10. PARTS OF THE TIMING ATTACHMENT

The whole ignition system is one of the most important details and to secure complete reliability under the peculiar conditions was no small task. The presence of water in the combustion chamber precluded everything but electric ignition and two high-power jump-spark systems are employed.

A special spark plug was required, incapable of being short-circuited by water. There is, in addition, a set of the conventional automobile plugs, spark coils and storage batteries for hand-wiring of the initial charge in starting.

All of the spark plugs for these several ignition systems are placed in the cylinder head, a steel casting of a flattened-dome shape. The induction coils, or transformers, are fastened as near to their respective plugs as possible to reduce the danger of leakage of high-voltage discharges and are protected as far as possible from moisture.

The domed head is also pierced with numerous holes for connections to admit air and gas for starting. Starting is easily carried out with a two-cylinder compressor, pumping air and gas in proper proportions by separate pipes to a T just outside the dome. The first cylinder full of inflammable mixture fired will often be enough to start the column, fill the play pipe with water and set up surges strong enough to make the pump pick up its regular cycle. The ignition and valve-interlocking system may be operated by hand and one of these huge pumps can be put in full operation from cold condition in less than a minute.

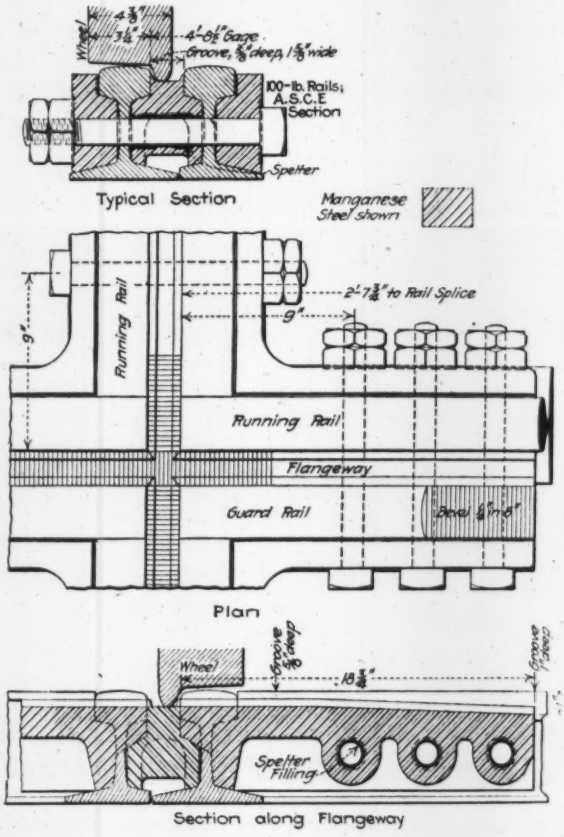
Once started, little skilled attention is required. There are none of the heating and lubrication troubles found with big gas engines,. The worst that can happen is to have the pump stop from lack of water, gas or ignition. With the means of supply for each of those duplicated, as in the Del Rio pump, this failure becomes only a remote possibility. The pump has been designed and the installation made under Humphrey and Smyth patents by the Humphrey Gas Pump Co., of Syracuse, N. Y. W. H. Smyth, of Berkeley, California, is the inventor who was among the first to raise water by direct explosion of fuel gas in the United States.

Flange-Bearing Track Intersections for Street Railways

To reduce the shock and pounding of wheels in crossing the gaps in rails at track intersections on street railways, it is a very general practice to build the special work for the intersection with the flangeways filled at the crossing frogs so as to engage the wheel flanges. In this way the wheel treads (including false flanges on worn wheels) are raised clear of the rail head and the wheels ride past the gaps on their flanges.

In earlier track construction of this type, the flange-bearing feature was soon lost or impaired by the wear of the flange filler. In modern construction, manganese steel is used to carry the flanges and sustain the wear, but in many designs (particularly those having hard-steel inserts at the crossing frogs) the parts are so short as to give a steep incline (about 1 in 16) for raising the wheel. This results in a sharp blow as the wheel flange engages the inclined end of the flangeway filler, and causes shock and vibration to the wheel and car as well as to the track and its foundation. This is especially the case with worn wheels having deep flanges.

In an improved design of flange-bearing track intersection, the manganese-steel flangeway fillers are made with end inclines of a very light angle (about 1 in 60) so as to engage and raise the wheels easily, whether they have standard or deep flanges. The fillers extend over the entire length of the crossing, and end in similar inclines which lower the wheels easily and smoothly to their normal tread-bearing position on the rails. This plan cannot well be employed with frogs having hard-steel inserts, as it is undesirable to use inserts of the length which would be required. It can be introduced readily with continuous fillers of manganese steel. The crossing shown in the accompanying drawing has a solid manganese-steel casting for the flangeway filler (upon which the wheel flanges ride), with an ordinary rail on each side.



STANDARD CONSTRUCTION FOR STREET-RAILWAY TRACK CROSSINGS OR INTERSECTIONS, WITH THE WHEELS RIDING ON THEIR FLANGES; METROPOLITAN STREET RY., KANSAS CITY, MO.

The cored holes in the manganese filler are filled with spelter. After the crossing is assembled these holes are drilled and reamed so as to give the bolts a driving fit.

This design practically eliminates wear and battering of the corners at the rail intersections and substitutes a rolling wear on the flangeway filler. The depth of flangeway as shown is ⅝ in. A sufficient depth must be allowed for guiding the wheels, but apart from this the shallower the flangeway is made the better, as it gives more metal for wear and a longer life for the crossing. The cost is somewhat higher than for track intersections of the ordinary types, but this is likely to be more than offset by the longer life of the crossing. The easy-riding property (with comparative noiselessness) is an impor-

tant advantage which is very evident to passengers and the public, and one which will have an effect in reducing the wear and tear upon track foundations and rolling stock.

Several crossings have been made in this way and have proved satisfactory in service. The shock and wear are much less than in other crossings, and a special feature is the reduction of noise as cars pass over the crossing. It is considered that this construction will be much more satisfactory than crossings of the cast-bound type with insert plates, and probably more satisfactory than crossings of solid manganese-steel castings. A proposed modification of the design shown is to use rolled manganese-steel rails for the running rails.

This form of track intersection or crossing is the design of A. E. Harvey, Chief Engineer of the Metropolitan Street Ry., Kansas City, Mo.

Test of Long-Submerged Hemlock Timber

By T. R. Lawson*

A compression test of a 12x12-in. hemlock stick which had been submerged about 40 yr. ago was recently made in the 600,000-lb. testing machine at Rensselaer Polytechnic Institute.

The timber was 16 ft. 9 in. long. It came from the grillage under one of the guard piers of the Congress St. bridge at Troy, N. Y., and had been under water for a period of about 40 yr. The pier from which it came failed shortly after the flood in the spring of 1913; the wreckage was removed from the river the following summer, and the timber was taken to one of the material-testing laboratories of Rensselaer Polytechnic Institute. It was kept in the open air for a period of 3 mo. and then placed in a dry room for a little over 9 mo. The process of drying out caused the timber to check somewhat along the center line. In addition, there were a number of 1-in. holes through it where driftbolts had been driven to hold the various layers of timber together in the grillage. These holes were all parallel, only one at a cross-section, and were spaced about 3 ft. apart.

The column failed under a load of 384,000 lb. Failure began by the opening up of the season checks at one of the bolt holes, which caused the timber to split in two parts, and was completed by the crushing of the extreme fibers near the center.

Comparing the results of the test with the C. Shaler Smith formula for average yellow-pine columns, viz.:

$$p = \frac{5000}{1 + \frac{l^2}{250\,d^2}}$$

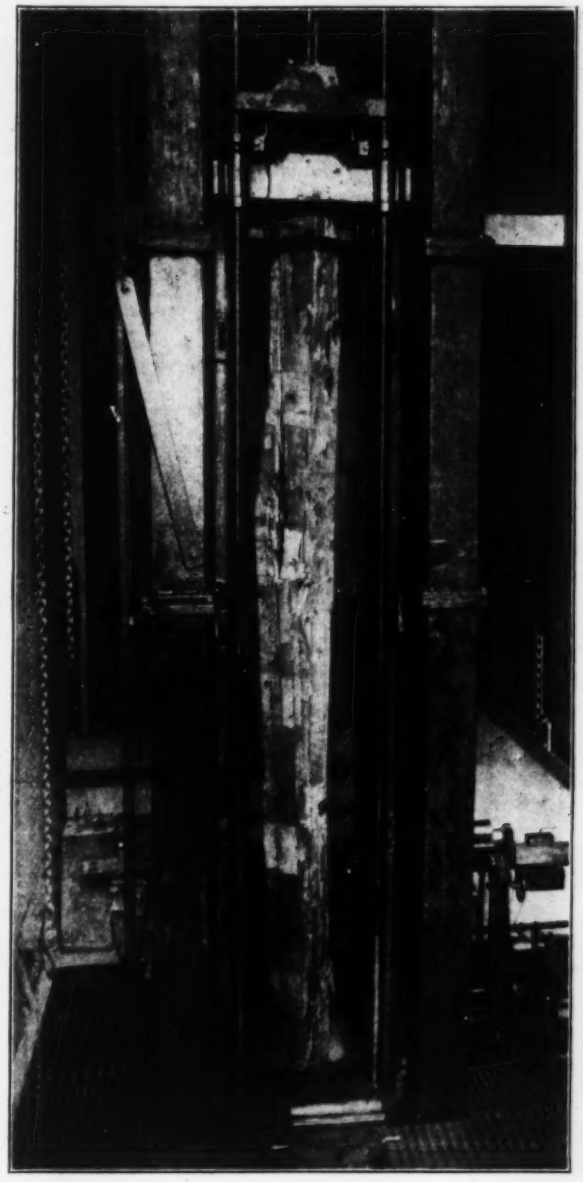
where

p = ultimate strength, lb. per sq.in.;
d = least dimension, in.;
l = length, in;

it will be seen that the constant of 5000 in the formula should be replaced by 4200.

The results from a single test of this character are by no means conclusive, yet the rather remarkable strength shown in this instance, considering that the material is hemlock, tends to indicate that immersion in water for such a long time does not decrease the column strength of timber if it be subsequently permitted to dry out.

It is expected that in the rebuilding of the Congress St. bridge, recently begun by the Fort Pitt Bridge Co., more timber of this character will become available for testing purposes.



Hemlock Stick in Testing Machine after 40-Year Submersion

(The timber was 12x12 in. by 16 ft. 9 in. It showed an ultimate strength of 2670 lb. per sq.in.)

*Professor of Rational and Technical Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y.

A Single Street Commissioner at Norwalk, Conn., since the consolidation in 1913 of that city with Norwalk, South Norwalk, the Fire District of East Norwalk and the former Town of Norwalk, has charge of the engineering work and all the street work formerly handled by two city engineers, a town engineer, three selectmen and two street commissioners. Such sewerage systems as existed are also under the jurisdiction of the street commissioner. Three separate water plants still exist, each under the charge of three commissioners. The office of Street Commissioner and City Engineer is now filled by G. A. Sherron.

Wind Pressure Formulas and Their Experimental Basis

By R. Fleming*

SYNOPSIS—A discussion of the current formulas for relation between wind pressure and velocity, relation between pressure on normal planes and planes inclined to the wind, and several other phases of wind pressure. The author brings out strikingly how inadequate is the experimental basis for the formulas and figures commonly employed. Later papers will discuss choice of wind-pressure values for mill buildings and bridges, and wind stresses.

The purpose of this article is to give the basis from which some of the commonly used formulas for wind pressure are derived. Even the engineer who wishes to know only the wind pressure in pounds per square foot for which he shall make provision in his structure will be better equipped for designing if he is acquainted with the foundations on which ordinary practice rests.

Relation between Wind Pressure and Velocity

In view of the extent of the literature on the subject it might reasonably be supposed that the elementary principles of wind pressure are determined, at least theoretically. How near this is to being the case may be inferred from the following extracts taken from two modern American textbooks, each of which is regarded as an authority. Marburg, in his *Framed Structures and Girders,* under "Wind Pressure," writes:

> Theoretically the pressure p in lb. per sq.ft., on a plane surface normal to the direction of flow of a fluid having a relative velocity v, in ft. per sec., is equal to the weight of a vertical column of the fluid having a cross-section of 1 sq.ft. and a height h in ft. equal to that through which a freely moving body must fall to acquire the velocity v. If w denotes the weight of the fluid, in lb. per cu.ft.,
>
> $$p = wh = \frac{wv^2}{2g} \qquad (1)$$
>
> For air at a temperature of 32° F. and at a barometric pressure of 760 mm., w = 0.081. Letting g = 32.2,
>
> $$p = 0.00126\ v^2 \qquad (2)$$
>
> If V denotes the velocity of the wind in miles per hour, v = 1.47 V, whence equation (2) becomes
>
> $$p = 0.0027\ V^2 \qquad (3)$$

Burr and Falk, in *The Design and Construction of Metallic Bridges,* under "Stresses due to Wind" write:

> If the wind were directed as a finite stream against an infinitely large surface, so that the direction of the air is completely changed, an equation expressing the force against that surface may be obtained from the laws of mechanics. Let
>
> W = the weight of air directed against any normal surface in a given time;
> w = the weight in pounds of one cubic foot of air;
> v = the velocity of wind in feet per second;
> a = the area of cross-section of the wind stream,
>
> Then W = wav.
>
> Let
>
> M = the mass of air of the weight W;
> g = the acceleration due to gravity = 32.2 feet per second;
> F = the force acting on the area a.
>
> Then $F = Mv = \frac{Wv}{g} = \frac{wav^2}{g}$ (1)
>
> If a be taken at 1 sq.ft., and w at 0.0807 lb. per cu.ft. for a temperature of 32° F. and a barometric pressure of 760 mm., and if v be replaced by V, the velocity in miles per hour, then
>
> $$F = 0.0054\ V^2$$

The reader will observe that starting with the same assumptions one author finds the resultant pressure to be twice that of the other. Both authors make haste to write that the theoretical conditions upon which their formula is based do not exist. A cushion of air is formed in front of the plate and a partial vacuum at the back; there is a certain amount of air friction and the change of direction is not complete. The student facing such conflicting theories on the very fundamentals of wind pressure may well raise the question of authority.

It is almost impossible to give undue credit to Sir Isaac Newton for his work in the realms of science and mathematics. His great book was the *Philosophia Naturalis Principia Mathematica,* or "The Mathematical Principles of Natural Philosophy," commonly called the *Principia.* Originally published in 1686, revised editions were issued in 1713 and 1726. Modern hydrodynamics had its origin in the second book, treating of Motion of Bodies in Resisting Mediums. Section VIII of this book is entitled "Of Motion Propagated through Fluids." A translation of Prop. XLVIII (Newton wrote in Latin) reads:

> The velocities of pulses propagated in an elastic fluid are in a ratio compounded of the subduplicate ratio of the elastic force directly, and the subduplicate ratio of the density inversely; supposing the elastic force of the field to be proportional to its condensation.

This means that the velocity v varies as $\frac{\sqrt{p}}{\sqrt{d}}$, or p varies as dv^2. For wind pressure, the density of the air being constant, we have the law that the pressure varies directly as the square of the velocity, which has remained almost undisputed since Newton's day.

Furthermore, according to Newton, for an area of unity, $p = dh$, in which $h = \frac{v^2}{2g}$ is the distance through which a heavy body must fall to acquire the velocity v, g being the coefficient of gravity or 32.2. This may be called the Newtonian theory, and has been followed by a host of writers, including Marburg (quoted above).

W. J. M. Rankine was one of the master mathematicians of the nineteenth century. In his fifteenth year his uncle presented him with a copy of Newton's *Principia,* which he read carefully. He remarks, "This was the foundation of my knowledge of the higher mathematics, dynamics and physics." But the pupil did not blindly follow the master. In his *Applied Mechanics,* he has a section devoted to "Mutual Impulse of Fluids and Solids." A jet of fluid A, striking a smooth surface, is deflected so as to glide along the surface in that path which makes the smallest angle with its original direction of motion. Let v be the velocity of the particle of fluid, q the volume discharged per second equal to Av, d the density, and θ the angle by which the direction of motion is deflected; then $\frac{dqv}{g}$ is the momentum of the quantity of fluid whose motion is deflected per second.

*American Bridge Co., 30 Church St., New York City.

With these notations the general equation for the force Fx perpendicular to the plane in question is found to be

$$Fx = \frac{dqv}{g}(1 - \cos\theta)$$

For the particular case of the plane at right angles to the jet or $\theta = 90°$

$$Fx = \frac{dqv}{g} = \frac{dAv^2}{g}$$

This may be called the impact theory, and is followed in some textbooks, including that of Burr and Falk.

From the time of Newton until this day a long line of investigators have sought by experiment to obtain the value of k in the formula $P = kV^2$, in which P = pressure in lb. per sq.ft. and V = velocity in miles per hour. As before noted, according to the Newton formula k is 0.0027 and with the same assumptions according to Rankine k is 0.0054. What is known as the Smeaton formula held almost universal sway for 150 years and is still in use. It is very simple, $P = {}^1/_{200}V^2$. In the Philosophical *Transactions* of the Royal Society, England, for the year 1759 is a lengthy paper entitled, *An Experimental Enquiry Concerning the Natural Power of Water and Wind to Turn Mills, and Other Machines, Depending on a Circular Motion. By Mr. J. Smeaton, F. R. S.* Part III is "On the Construction and Effects of Windmill-Sails." For his experiments Smeaton constructed an elaborate machine or whirling-table in which fixed sails revolved through the air about a given axis and their velocities were measured by the weights lifted. A footnote reads:

Some years ago Mr. Rouse, an ingenious gentleman of Hasborough in Leicestershire, set about trying experiments on the velocities of the wind, and force thereof upon plain surfaces and windmill sails.

It is presumed, though not so stated, that Mr. Rouse used a whirling-table similar to that described by Smeaton. Further on in the paper a table "containing the velocity and force of wind, according to their common appellations," is found introduced with:

The following table which was communicated to me by my friend Mr. Rouse, and which appears to have been constructed with great care, from a considerable number of facts and experiments, and which having relation to the subject of this article; I here insert as he sent it to me; but at the same time must observe that the evidence for those numbers where the velocity of the wind exceeds 50 miles an hour, do not seem of equal authority with those of 50 miles an hour and under. It is also to be observed, that the numbers in column 3 are calculated according to the velocity of the wind, which in moderate velocities, from what has been before observed, will hold very nearly.

From this introduction it is impossible to tell where experiment ended and theory began. The coefficient of V^2 according to the figures given in the third column of the table is found to be 0.00492, or ${}^1/_{200}$ nearly. It is hard to understand how a formula resting upon such a slender foundation should have had such wide vogue.

The most careful experiments of recent years for the pressure on flat plates of moderate size normal to the direction of a uniform wind give a value of k from 0.0032 to 0.004. Hence the formula $P = 0.004\,V^2$ may be safely used. It is interesting to note that Weisbach, in his monumental work, the *Mechanics of Engineering*, followed Newton's method but multiplied the value of k as found by this method by a coefficient 1.86, stating that about two-thirds of the action is upon the front and about one-third upon the rear surface. He based his coefficient upon the experiments of Dubuat (about 1780) and Thibault (1826).

The U. S. Weather Bureau uses the formula

$$P = 0.004\frac{B}{30}V^2$$

in which B = height of barometer in inches. This for the engineer is an unnecessary refinement as $\frac{B}{30}$ varies but little from unity. Wolff in his book *The Windmill as a Prime Mover* takes into account also the effect of temperature in determining wind pressure. At sea level for a wind velocity of 40 miles per hour he finds pressures of 8.6 lb. per sq.ft. for 0° F. to 7.08 lb. for 100° F. For a velocity of 80 miles per hour he finds pressures of 34.98 lb. per sq.ft. at 0° F. to 28.86 lb. at 100° F.

Wind-Pressure Coefficient for Inclined Surfaces

For the intensity of wind pressure on inclined surfaces we have a wide range of values from which to choose. Tiberius Cavallo, F. R. S., etc., in 1803, published a four-volume treatise on *The Elements of Natural or Experimental Philosophy*. The writer has never seen the treatise quoted, but Chapter IV of Book II, "Of the Action of Nonelastic Fluids in Motion," and Chapter X of the same book, "Of Air in Motion, or of the Wind," are written in a truly scientific spirit and are readable today. A proposition of Cavallo's reads, "The forces of a fluid medium on a plane cutting the direction of its motion with different inclinations successively, are as the squares of the sines of these inclinations." This, however, is implied by the great Newton in the *Principia*, Book II, Prop. XXXIV. Among recent writers Spofford in "The Theory of Structures" deduces the same theoretical results.

As these results differ widely from those obtained by experiment, recourse must be had to empirical formulas. Among such, Hutton's formula has been used in England and the United States perhaps more than all others combined. It is still found in the latest editions of many technical books. The experiments upon which it is based were decidedly crude. Tract XXXVI of *Tracts on Mathematical and Philosophical Subjects* by Charles Hutton, LL.D., F.R.S., Professor of Mathematics in the Royal Military Academy of Woodwich, England, entitled, "Resistance of the Air Determined by the Whirling-Machine," records his experiments. Hutton secured a whirling-machine and during 1786 and 1787 experimented with hemispheres and cones. Under date of July 23, 1788, he records:

Prepared the machine to make experiments with figures of shapes different from the foregoing ones. Procuring a thin rectangular plate of brass to fix on the arm of the machine; its weight 11½ oz. and its dimensions 8 in. by 4 in., consequently its area was 32 sq.in. . . . It was adapted for fitting on the end of the arm in both directions, . . . It was also contrived to incline the surface in any degree to the direction of motion, to try the resistance at all angles of inclination. When fitted on with its length in the direction of its arm, the distance of its center from the axis of motion was 53¾ in.; and the same distance also when fitted on the other way.

Experiments were carried on at different inclinations of plate with a velocity of 12 ft. per sec. or 8.2 miles per hour. When attempting to bring the velocity up to 20 ft. per sec. or 13.6 miles per hour, the thread carrying the weight broke. These experiments are recorded under

dates of July 24, 25, 31 and Aug. 11. The results obtained were tabulated and the well known formula

$$P_n = P\ (sin\ x)^{1.84\ cos\ x\ -\ 1}$$

was deduced. This is sometimes called Unwin's formula though for what reason is not clear, as Prof. Unwin simply quotes Prof. Hutton's formula approvingly.

The Duchemin formula

$$P_n = P\frac{2\ sin\ A}{1 + sin^2\ A}$$

for inclined surfaces may be said to represent the best knowledge on the subject and is considered the most reliable formula in use. The pressures obtained are greater than those from the Hutton formula. Col. Duchemin, a French army officer, made his investigations in 1829 and the results were published in 1842 (Bixby).* Considerable weight has been attached to the work of Col. Duchemin. Weisbach quotes it, as well as most writers since his time. The Duchemin formula was verified by S. P. Langley in 1888. He had erected at the Allegheny (Penn.) Observatory a whirling-table consisting of two symmetrical wooden arms, each 30 ft. long, revolving in a plane 8 ft. above the ground. The motion thus obtained was nearly rectilinear, quite in contrast with that from Hutton's machine of less than 5-ft. radius. He also used velocities up to 100 ft. per sec., or nearly 70 miles per hour. He writes:

> At the inception of the experiments with this apparatus it was recognized that the Newtonian law, which made the pressure on an inclined surface proportional to the square of the sine of the angle, was widely erroneous. Occasional experiments have been made since the time of Newton to ascertain the ratio of the pressure upon a plane inclined at various angles to that upon a normal plane, but the published experiments exhibit extremely wide discordance, and a series of experiments upon this problem seemed therefore, to be necessary before taking up some newer lines of inquiry.

It is remarkable that Langley obtained results varying less than 3% from those derived from the Duchemin formula. Regarding this he writes:

> Only since making these experiments my attention has been called to a close agreement of my curve with the formula of Duchemin, whose valuable memoir published by the French War Department, "Memorial de l'Artillerie" No. V, I regret not knowing earlier.

Attention is called to the monographs by Langley, *Experiments in Aërodynamics* and *The Internal Work of the Wind*, being Numbers 801 and 884 of the "Smithsonian Contributions to Knowledge."

Wind Pressure on Nonplanar Surfaces

When the wind blows on nonplanar surfaces the pressure on the projected area depends upon the form of the surface. This is important in the case of the cylinder (standpipes, chimneys and similar objects). Rankine states in his *Applied Mechanics*, "The total pressure of the wind against the side of a cylinder is about one-half of the total pressure against a diametral plane of that cylinder." A theoretical value of two-thirds is found in some treatises, but in engineering practice one-half is generally used.

Goodman in his *Mechanics Applied to Engineering*, London, 1904, gives the following ratios of pressure:

Flat plate	1.0
Sphere	0.36 to 0.41
Elongated projectile	0.5
Cylinder	0.54 to 0.57
Wedge (base to wind)	0.8 to 0.97
Wedge (edge to wind)	0.6 to 0.7
Vertex angle 90°	
Cone (base to wind)	0.95
Cone (apex to wind)	
Vertex angle 90°	0.69 to 0.72
Vertex angle 60°	0.54
Lattice girders about	0.8

Wind Pressure on Parallel Plates

The pressures upon parallel plates or bars with an open space between them are important in application to plate-girder bridges, the trusses in a truss bridge, or parallel bars in the same truss when one bar is behind another.

The Committee of the National Physical Laboratory, England, having decided that one of the first researches to be undertaken in the Engineering Laboratory should be the investigation of the distribution and intensity of the pressure of wind on structures, an elaborate series of experiments was conducted by Thomas Edward Stanton and the results embodied in two papers contributed by him to the Institution of Civil Engineers: "On the Resistance of Plane Surfaces in a Uniform Current of Air" and "Experiments on Wind Pressure." For circular plates 2 in. in diameter at 1½ diameters apart, he found the value of the total pressure was less than 75% of the resistance on a single plate; at 2.15 diameters apart the total pressure was equal to that on a single plate; while at a distance of 5 diameters apart the total pressure was 1.78 times that on a single plate. Stanton's first experiments were criticized because they were conducted with such small models. For his second series he built a tower and used larger surfaces, but found little to change his previous conclusions.

Baker's experiments at the Forth Bridge led him to the conclusion that in no case was the area affected by the wind in any girder which had two or more surfaces exposed more than 1.8 times the area of the surface directly fronting the wind. The Board of Trade regulations under which the Forth Bridge was built required that a wind pressure of 56 lb. per sq.ft. should be used in calculations, and this twice over the area of the girder surface exposed.*

Measuring Wind Pressure and Velocity

It has been assumed by experimenters that the pressure of the wind on a given shape with a certain velocity is the same as that of the shape moving through the air with an equal velocity. This seems to follow from Newton's Corollary V to his Laws of Motion, "The motions of bodies included in a given space are the same among themselves, whether that space is at rest or moves uniformly forward in a right line without any circular motion." Perhaps the only dissonant voice is that of T. Claxton Fidler, who in his *Bridge Construction* writes: "But it has not yet been ascertained that the pressure of the wind is the same thing as the resistance offered by the air to a moving body."

The pressure of the wind has been measured direct and independently of the velocity. The methods of doing this

*The writer, while obtaining his information first hand from the sources quoted, acknowledges an obligation to a valuable report: Appendix C of the Report of Sept. 29, 1894, of the Special Army Engineer Board as to the Maximum Span Practicable for Suspension Bridges. By W. H. Bixby, Captain (now General) of Engineers, U. S. A. It is really a treatise on wind pressure in engineering construction. It is said only 500 copies were issued. This valuable paper may be found reprinted entire in "Engineering News," Mar. 14, 1895.

*Engineers regard the requirement of 56 lb. as needless and excessive.

are so limited in their application that the pressure is almost universally determined in terms of the velocity. Hence, the prime importance of measuring the velocity of the wind correctly. Attempts to do this have been made by all manner of means for the past two centuries. The science of Anemometry has a literature of its own. The velocities obtained by all methods are more or less in error—some of them very much so. At present the Robinson Cup Anemometer or some modification of it is used pretty generally throughout the meteorological world for measuring wind velocities.

In the *Transactions* of the Royal Irish Academy, Vol. XXII, part III (1852), is a paper: "Description of an Improved Anemometer for Registering the Direction of the Wind, and the Space Which it Traverses in Given Intervals of Time. By the Rev. T[homas] R[odney] Robinson, D.D., Member of the Royal Irish Academy, and of other Scientific Societies. Read June 10, 1850." Dr. Robinson, who was connected with the observatory at Armagh, Ireland, writes:

> After some preliminary experiments I constructed in 1843 the essential parts of the machine, a description of which I now submit to the Academy, and I added in subsequent years such improvements as were indicated by experience. It was complete in 1846, when I described it to the British Association at Southampton.

He found "from sixteen experiments made in four days with winds from a moderate breeze to a hard gale,

$$\frac{a}{a'} = 4.011$$

or, in round numbers, the action on the concave is four times that on the convex." From this he found the theoretic value m of the ratio of the velocity of the wind to that of the cup center to be $m = 3.00$. Dr. Robinson concluded that no matter what the size of the cups or the lengths of the arms, "the centers of the hemisphere move with one-third of the wind's velocity, except so far as they are retarded by friction." This has been disproved. As a necessary result, many published velocities are in error.

The U. S. Weather Bureau prescribes that each pattern of anemometer should have its particular law of rotation determined by special experiment. Its standard instruments in use throughout the United States have hemispherical cups 4 in. in diameter on arms 6.72 in. long from the axis to the center of the cups. To the observed velocity the correction Log. $V = 0.509 + 0.912$ Log. v is applied in which V is the actual velocity of the wind and v is the linear velocity of the cup centers, both expressed in miles per hour.

Effect of Variations within the Wind

Measurements of either wind velocity or wind pressure are complicated enormously by the variations in the wind. This is illustrated by two observed facts, both of which are vitally important to the structural engineer:

1. Wind pressures are less per unit of area for large surfaces than for small ones. On the Forth Bridge two pressure boards were set up, one 20 ft. long by 15 ft. high, and 8 ft. from it a circular plate of 1½ sq.ft. area. The maximum pressure registered on the small plate during the years 1884 to 1890 was 41 lb. per sq.ft. The large board showed at the same time a pressure of 27 lb. per sq.ft. The readings for the large board never exceeded 80% of those recorded for the small plate at the same time, and generally were 50 to 70%. A technical journal of the time hastily drew the inference from these experiments that pressure per square foot varies inversely as area, the velocity remaining the same—another illustration of generalizing from insufficient data!

2. Wind velocity increases with the distance from the ground. Thomas Stephenson from his experiments writes the equation

$$V = V_1 \frac{\sqrt{H}}{\sqrt{H_1}}$$

or

$$V^2 : V^2_1 : : H : H_1$$

A limiting unit of height must be established for this equation to be of any use. An anemometer placed at the top of the Eiffel Tower, an elevation of 994 ft., and another in the meteorological office at an elevation of 69 ft., showed for light winds velocities nearly four times as great at the top of the tower as at the office. For higher winds the velocities came nearer together.

Conclusion

Cavallo, previously quoted, wrote, "a great many more experiments must be instituted by scientific persons before the subject can be sufficiently elucidated." More than a hundred years after Cavallo's writing, the U. S. Weather Bureau in its monograph on *Anemometry*, after giving values for pressures and velocities with all the refinements at its command, says:

> Great dependence cannot be placed in these values for indicated velocities beyond 50 or 60 miles per hour, as thus far direct experiments have not been made at the higher velocities, though it is probable the corrected values are throughout much more accurate than values computed from older formulas and uncorrected wind velocities.

Structures have long been designed with satisfactory results to withstand wind pressure. The bracing at times may have been excessive, but in the absence of better knowledge on the subject, engineers cannot radically depart from present practice.

[Editor's Note.—In other papers soon to be published, Mr. Fleming discusses wind pressure with specific relation to mill buildings and bridges.]

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Malarial Surveys of Impounded Waters have been undertaken by the United States Public Health Service. The object of the surveys is to learn the relation between impounded water and malaria as spread by mosquitoes, and more particularly to learn "what measures can be taken to minimize the ill effect of such waters and to increase to a maximum their good effect." General statements regarding the plan and scope of the surveys are published in "Public Health Reports" (Washington, D. C.) for Dec. 25, 1914, and a report on the natural survey of a power-plant reservoir at Blewetts Falls, N. C., is outlined in the publication of the same name for Jan. 1, 1915. Both articles are by H. R. Carter, Senior Surgeon, United States Public Health Service. The investigations appear to be confined to reservoirs formed by dams for power plants. An outline of such a malarial survey is given toward the close of the first of the articles named. The main conclusion of a general consideration of this subject is as follows:

> From the foregoing it does not seem probable that Anopheles will be found breeding to a considerable extent in large ponds, except in that zone in which the banks are just overflowed, or about to be overflowed, and in creeks and branches at places where similar conditions of banks prevail. In the bayous and creeks where larvae may be sheltered by drift and protected by the conformation of the shore from wave action some breeding will also be found.

In summarizing the results of the survey at Blewetts Falls, Dr. Carter states, among other things, that

> This pond has enormously diminished the area of breeding places of Anopheles, both next to the river and in the valleys of the creeks.

It is pointed out, however, that the conclusions stated are drawn from conditions found in the summer of 1914. This pond is relatively new and the conditions are neither the same as they were when it was first filled nor as they will doubtless be a few years hence.

Lining the St. Louis Water Tunnel with Concrete by Means of Compressed Air

By E. C. Davis*

The new intake tunnel of the water-works of St. Louis, Mo., is 8 ft. diameter, is driven through rock, and extends from the pumping station to an intake shaft in the Mississippi River. The contractor's plant and methods for driving the tunnel were described in Engineering News, May 14, 1914, p. 1058. The present article describes the placing of the concrete lining by means of compressed air.

The working shaft, 96 ft. deep, was located approximately 100 ft. from the river. The river tunnel extends

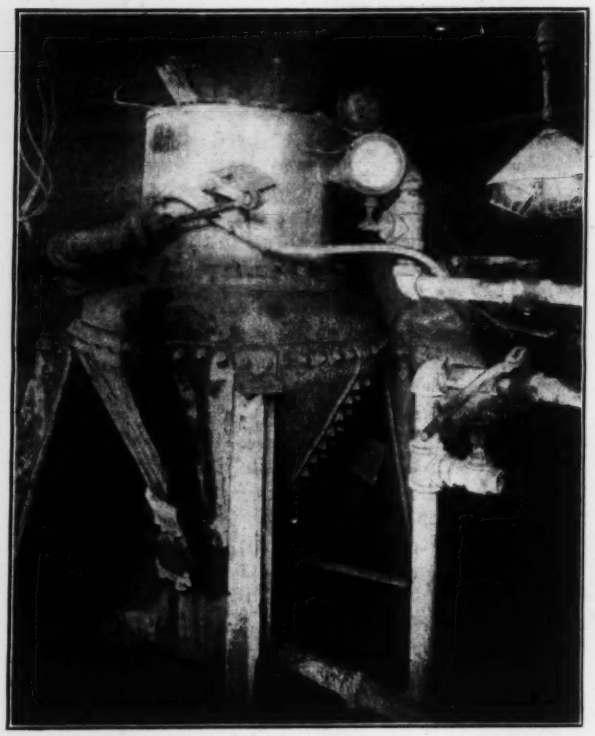

Fig. 1. Pneumatic Device for Mixing and Distributing Concrete for Lining the New Water Intake Tunnel at St. Louis, Mo.

eastward under the Mississippi River a distance of approximately 2300 ft. to the new intake tower, and the shore tunnel extends westward about 560 ft. to the wet wall at the pumping station. The concrete lining varied from 9 to 20 in. thick. It was a 1:2:4 mix, made with gravel ranging from ¼ to 1½ in. diameter. No steel reinforcement was required.

The compressed air for this work was furnished by the plant originally provided for driving the tunnel, and consisted of one straight-line machine and one two-stage compressor, with capacities of 650 and 950 cu.ft. per min. at 110-lb. pressure.

The mixer and conveyor used (¼-yd. capacity) is shown in Fig. 1. Air was piped down the shaft through a 4-in. line, reduced to 3 in. at the bottom. The three smaller pipes shown entering the mixer are connected to this 3-in. line. The lower pipe is 2 in. diameter and is connected to the elbow end of the 8-in. discharge pipe by means of which the concrete is conveyed to the forms. The upper pipe, 1½ in., enters the mixer near the top, and the action of the air due to the relative positions of these two pipes prevents the bottom of the machine from becoming clogged, while it also thoroughly mixes the concrete during transportation. The small air hose supplies the air to the cylinder on the side of the mixer, and its function is to close the door at the top of the machine when the batch of concrete material has entered the mixer. This door prevents the escape of air from the mixer top when the transporting air blasts are applied.

Two sets of forms 36 ft. in length were used on this work. They were built of structural angles and channels, with wood lagging covered with light sheet metal securely nailed to the lagging. However, this sheet metal was removed at an early stage and a better finish of the concrete was obtained by using plain wood lagging kept well oiled. The forms were portable and supported on two small trucks running on a track of 24-in. gage, placed on the finished invert. The forms were provided with screw jacks built on the trucks for lowering and raising, and with turnbuckles which were used to pull the wings inward to provide the clearance when moving the forms.

The pipe and concrete material were transported by the wooden muck cars and a 25-hp. storage-battery locomotive originally provided for driving the tunnel.

Concreting the Shore Tunnel

The shore tunnel was first lined. The pneumatic mixer and conveyor was set at the bottom of the shaft. The cement, sand and gravel were loaded directly into the mixer from the top of the shaft by building a hopper at the shaft top with a 10-in. pipe leading down and discharging directly into the mixer. The hopper was made with a sliding horizontal door at the bottom. Upon a signal from the man at the mixer, this door was opened by means of a lever, allowing the measured batch to drop directly into the chamber of the machine. The man who operated this door also admitted the water from a barrel at the same time the batch was dropped. This water had a tendency to clog the chute, so a 2-in. water pipe was provided to deliver the water into the mixer hopper at the bottom of the shaft.

One set of forms 36 ft. long was set up approximately 70 ft. from the west end of the shore tunnel. The 8-in. discharge pipe with flange couplings was laid extending through the forms, and concrete was placed for approximately 70 ft. of invert. After this section of the invert was placed, the track was laid at the proper elevation, carefully centered, and the forms were pushed back over the completed invert and made ready for concreting the arch. Heavy bulkheads were built at both ends of the arch with sandbags, as shown in Fig. 3. This proved to be very effective.

The discharge pipe was laid along the tunnel from the mixer to within 20 ft. of the forms and here an elbow of 22½° was inserted. Then a 20-ft. length of pipe was added, which brought the discharge pipe up to the roof of the tunnel, and here another 22½° elbow was placed. Then a piece of galvanized pipe about 18 ft. long was placed, which carried the end of the pipe over the forms

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to about the middle. This pipe was originally used for ventilation. It was easily handled and placed, but had to be renewed every third day.

Concrete Invert for the River Tunnel

While the shore tunnel was being lined, the river tunnel was made ready to receive the lining. A scheme of placing the concrete in the invert throughout the river

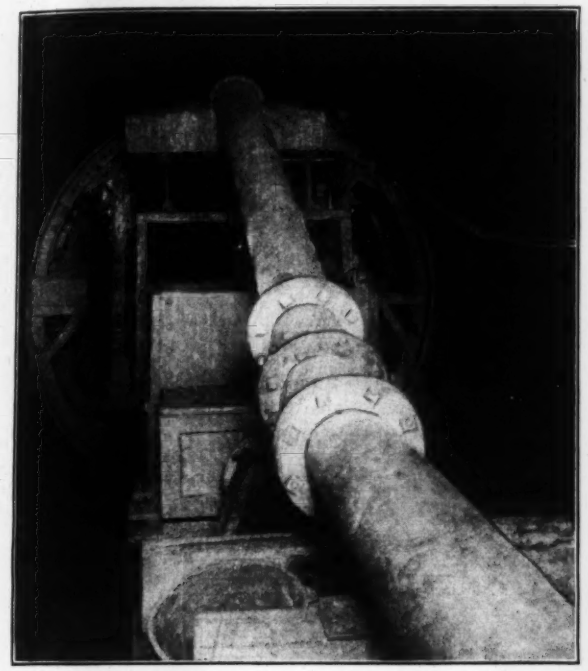


Fig. 2. Pipe Elevated above Invert

tunnel by hand was adopted by the contractor, and proved a saving in time as well as in expense. No forms were used for this portion of the work.

The concrete was mixed at the top of the shaft, loaded into a hopper and dropped down the shaft through a 16x16-in. chute, with 1-in. bolts staggered 2 ft. c. to c., which afforded further mixing. Cars of 24-cu.ft. capacity were placed under the chute and were hauled by the electric locomotive. A schedule was arranged by which the concrete would remain in the cars no more than 6 or 8 minutes before being deposited. Two cars were considered a load and a round trip was made in 10 to 12 minutes.

Profiles or templates of 4-ft. radius and of quarter section were placed 10 ft. c. to c. They were carefully set and braced at the proper line and grade. The concrete was deposited rather dry, being well tamped, and finished between the profiles by means of a straight-edge and a trowel. The finish obtained by this method was entirely satisfactory. The work was begun May 4 and completed June 2, 1914, a total of 25 working days. The average progress was 87 ft. per day of nine hours. The concrete averaged 0.49 cu.yd. per lin.ft. of invert.

Concreting the Arch of the River Tunnel

The invert in the river tunnel was finished a few days before the lining of the shore tunnel, which made possible the immediate removal of the mixer and forms to the river tunnel. With the air capacity available, it was decided not to shoot the concrete more than 1100 ft. The mixer was moved to a point approximately midway between the shaft and the end of the tunnel, and placed in a hole 4 ft. deep so that the top of the machine was approximately 18 in. below the center of the tunnel. The tracks were elevated on a platform, so that the cars were unloaded directly into the mixer.

The material for the concrete was measured in the hopper originally provided for concreting the invert, and was dumped through the chute into the cars and then hauled directly over the mixer. The cars were of the side-dump type and the material was transferred to the machine very rapidly. A 1-in. pipe was run through the tunnel to the mixer and the water delivered directly into the hopper of the machine. Two sets of forms were set up, one at the end of the tunnel, 1100 ft. from the machine, and the other 500 ft. from the machine. The discharge pipe was elevated 3 ft. above the invert so that it would run through the first set of forms and not interfere with the moving. This is shown in the view in Fig. 2.

The first effort to shoot concrete into the forms at the end of the tunnel was more or less a failure and it was decided as a remedy to place two air receivers (125 and 100 cu.ft. capacity) in the tunnel at the mixer. This relieved the situation and little or no trouble was experienced in shooting the concrete the required distance. The forms were poured alternately, requiring from two

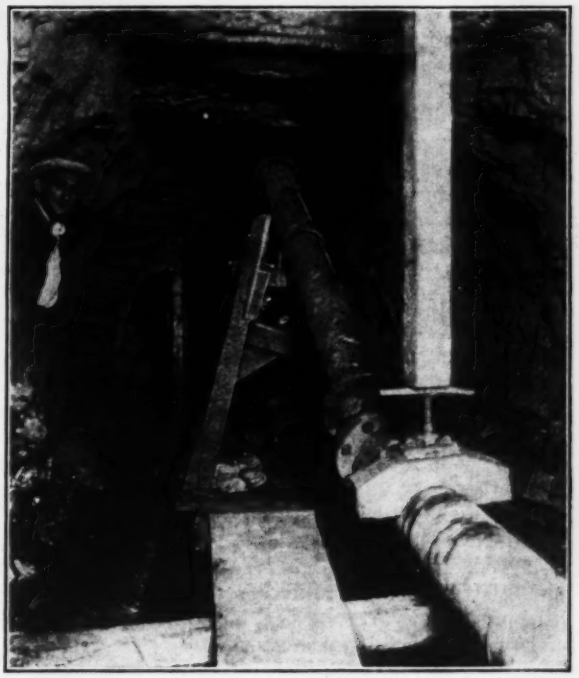


Fig. 3. Sand Bag Bulkhead with Pipe Passing Behind.

to four hours, depending upon the distance between the mixer and the forms.

While this portion of the tunnel was being lined, a perceptible difference in the quality of the concrete at the rear and the front of a form was noticed. Investigation

showed that the gravel in the concrete was discharged at a high velocity and deposited in the rear part of the forms, while the mortar would drop almost directly from the end of the pipes about midway of the forms. To overcome this, a 10-in. galvanized pipe 12 ft. long was slipped over the 8-in. discharge pipe leading from the end of the arch to the center. This pipe was made loose, so that as the forms were filled it could be slipped back, thus keeping the end of the discharge pipe no more than 4 ft. from the place where the concrete was being deposited. This device proved quite effective, and the quality of concrete was more uniform throughout the form.

After the part of the river tunnel between the mixer and the end was completed, the mixer was again moved to the bottom of the shaft. One set of forms was pulled ahead on the track to a point 500 ft. from the machine, and the concreting was handled in the same manner as was employed in lining the shore tunnel.

Progress

The work of lining the shore tunnel was begun Apr. 28 and completed May 22, a total of 20 working days. During this time 446 lin.ft. of tunnel lining was poured (including both invert and arch), an average of 22.3 ft. per day. The progress was rather slow, due to the fact that only one set of forms could be used, the tunnel being short. Faulty details in design had to be overcome, and new methods adopted after a series of experiments.

The work of lining the river tunnel was begun June 5 and completed Aug. 3, a total of 69 days. Ten days were Sundays, on which no work was performed; six days were lost, due to a fire which destroyed the compressor house, and three days were consumed in moving the machine. This leaves a total of 50 working days, during which 2167 lin.ft. of arch was completed, an average of 13.4 lin.ft. per day. Two sets of forms were used and poured alternately; the forms were pulled from 12 to 16 hr. after being poured, and in a great many cases two arches were poured in 24 hr. Each form held from 100 to 125 batches, each batch consisting of 1½ sacks of cement, 3 cu.ft. of sand and 6 cu.ft. of gravel, making approximately 40 cu.yd.

Force

The concreting force employed during this work varied, depending upon the number of arch sections poured per day. The average force per day consisted of the following: 1 superintendent, 1 compressor engineman, 1 fireman, 2 men loading materials from the cars to the storage yards, 4 to 5 men wheeling material from the storage yard to the hopper at the top of the shaft, 1 motorman (who also took care of the gang of 2 to 3 men doing odd jobs and maintaining the track), 1 foreman and 6 laborers moving forms and adjusting the discharge pipe preparatory to concreting, 1 man on the forms while the concrete was being poured, and 1 concrete finisher.

General Features of the Work

After the lining was completed, quite a number of hollow places were discovered between the top of the concrete and the roof of the tunnel. These were caused by small rock projections from the roof. The concrete traveling at high velocity would hit these projections and be deflected to either side, thus leaving holes directly behind the projections. The hollows varied from 3 to 8 in. deep.

The concrete was carefully sounded throughout the tunnel, and where a hollow was discovered a 2-in. hole was drilled with a "Jackhamer" drill, grout pipes were inserted and the hole filled with 1:2 grout. A Ransome-Canniff grout machine was provided and a pressure of 90 lb. was maintained. Where honeycomb places existed in the concrete this grout was forced into the voids and thereby strengthened such weak spots.

Delays were frequent, due to the insufficient air capacity when the concrete was being shot a distance of 500 to 1100 ft. In the writer's opinion this was due to the discharge pipes being too large in relation to the 1-yd. mixer. The amount of air consumed varied from 1.2 to 1.7 cu.ft. of free air per lin.ft. of discharge pipe. A pressure of 110 lb. was maintained at the receiver, and by the time the batch had been discharged the pressure was reduced 25 to 40 lb., depending upon the length of the discharge pipe. There is no doubt that if a 6-in. (instead of 8-in.) discharge pipe had been used the consumption of air would have been materially reduced, thus effecting a better progress and a saving of expense.

Engineers and Contractors

This work was done under the direction of Edward E. Wall, Water Commissioner, and Gordon G. Black, Engineer in Charge of the Supply and Purifying Division. The Fruin-Colnon Contracting Co., of St. Louis, had the general contract and leased the concreting apparatus from the Concrete Mixing & Placing Co., of Chicago. The writer, as Assistant Engineer, was directly in charge of construction.

An Ash and Refuse Dumping Board, West 77th St., North River, New York City

By C. W. Staniford*

The operation of dumping ashes and refuse into scows from an open dumping board has been one productive of great annoyance and discomfort in its immediate neighborhood. With a view to eliminating these objections the covered dumping board now in course of erection at West 77th St., North River, has been designed by the Department of Docks and Ferries of the City of New York.

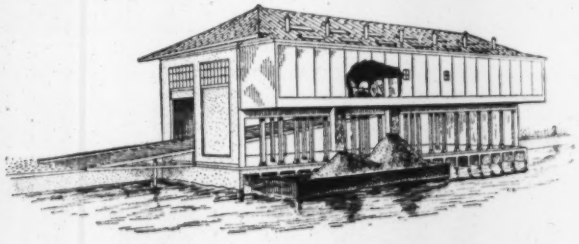


Fig. 1. Architect's Perspective of Covered Dumping Board Located at 77th St., North River, New York City

As a result of study the Dock Department some time ago designed a dumping board which was completely inclosed between two piers. The covering extended from out-to-out of these piers, so that the dust nuisance was

* Chief Engineer, Dept. of Docks and Ferries, New York City.

eliminated. This dumping board was not built, however, because of the great amount of property involved, the expensive shed required, and the difficulty in carrying on dredging operations inside the entirely covered house.

The present dump is located on the river side as on a one-sided pier and, as is shown in the perspective in Fig. 1, consists of a shed covering an incline which leads up to a second-story cantilever floor, from which floor the refuse and ashes are dumped in movable chutes to the scows underneath. A number of novel features have been introduced in the design of this dump, which may be enumerated as follows: (1) It will be founded on a reinforced-concrete platform or slab thus eliminating all timber above high water, with consequent protection against rot and fire; (2) the building itself above the platform is of steel,

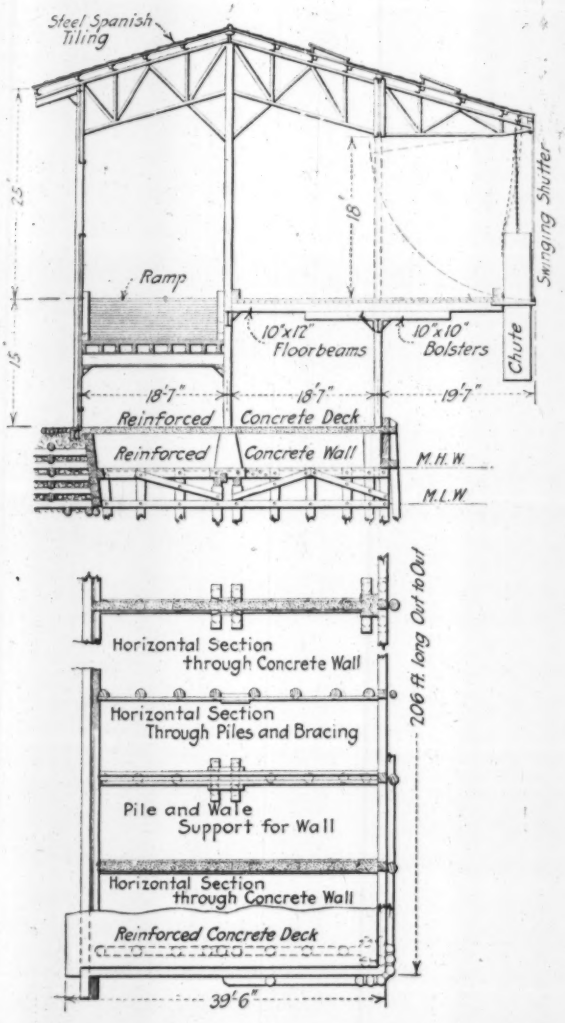


FIG. 2. DETAILS OF CONSTRUCTION OF THE 77TH ST. DUMPING BOARD, NEW YORK CITY

except the timbers of the deck system which are necessary for renewal and for the proper handling of horses on the ramp; (3) the outside is of stucco with ornamental steel tile roof so to make the structure as pleasing to view as possible; (4) the operation of dumping will be through steel chutes adjusted so as to carry the ashes from the cart without any exposure directly to the deck of scow or to the top of the load in scow. This avoids the difficulty previously experienced in all dumping boards of the dispersal of the ashes and dust over all surrounding property; (5) the river side of the dumping floor is covered from exposure by steel swinging doors which swing inward under the cantilever roof when any dredging is required, leaving a clear opening for the dredging beneath the dumping floor, a very necessary requirement.

The structure is situated in front of the present crib bulkhead at the foot of West 77th St., Manhattan, and consists in general of a reinforced-concrete platform about 40 ft. wide and 200 ft. long, at an elevation of 15 ft. above the street level, from which access is obtained by an incline of low grade. The supporting structure for the shed is a reinforced-concrete slab at street level (see Fig. 2) consisting of a series of walls supporting a deck on which are placed the columns of the upper structure, the sustaining walls of the platform being widened out to form pedestals at the points where the columns rest. These walls are founded on rows of wooden piles cut off at mean high-water line, connected by wooden ties and stiffened with diagonal braces of wood. The exposed end and front of the concrete platform are protected by wooden centering of square timber and oak piles.

The steel shed is inclosed in a stucco wall and is lighted on the land side by a continuous row of fixed windows. The roof is provided with a series of skylights.

The dispersion of the ashes by the wind in dumping from cart to scow is the particular objection to all street cleaning dumping boards. A method for overcoming this previous difficulty, consisting of adjustable chutes, was worked out by the Dock Department, through the original and novel suggestion of Commissioner R. A. C. Smith. Along the outboard side of the dumping board there are a number of these vertical chutes which can be raised or lowered independently of each other by means of hand chains operating differential pulley blocks (Fig. 2). By this means the mouth of any chute can be brought close to the gradually accumulating heap of refuse on the deck of the scow, thus reducing to a minimum the area of the stream of ashes or refuse exposed to the action of the wind. Each chute has two double-hinged doors swinging back into the chute so as to give uninterrupted passage to the dumped material, only one door being opened at a time according to the position of the chute. The outside of the dumping floor is practically a series of closely adjoining swinging doors which can be triced up to give free swing to the dredge buckets between the cantilever beams of the dumping board, the fascia logs also being removed for this purpose.

The structure was designed and is being supervised by the Department of Docks and Ferries under R. A. C. Smith, Commissioner; R. C. Harrison, First Deputy Commissioner, and C. W. Staniford, Chief Engineer. The Riverside Contracting Co. is contractor.

Steel Ties made of rolled channels, with wood blocks under the rails, are being tried on the Northern Pacific Ry. About 100 were laid in 1911, but some of these have been removed on account of difficulties in shimming track. During 1914 about 320 were put in, mainly at water stations where wooden ties were burned by cinders dropping from the engines. These ties were made by the Universal Metallic Tie Co., of Salt Lake City, Utah, and have been tried also on some other roads. Ties of this general type, but under various names and with various modifications in the rail fastening, have been used experimentally at different times within the past 30 years.

Brick Pavement Experience in Toronto, Ont.*

The first brick pavement in Toronto, Ont., was laid in 1895. Since then brick pavements have steadily increased in popularity and in the number of square yards laid. Up to the close of the year 1912 there were approximately 420,000 sq.yd. of brick pavement laid on a concrete foundation, varying from 4 to 6 in. in depth; 15,031 sq.yd. laid on a broken-stone base; 32,009 sq.yd. laid on gravel. In 1913 there were 1,207,892 bricks laid.

Of this number 727,160 were wire-cut-lug bricks. This was the first year that any brick of this type was laid in the city. They were laid on Merton St. in North Toronto, from Yonge St. to a point 2300 ft. east, as a test, and they proved so satisfactory that Toronto is now specifying this type exclusively. The pavement is 28 ft. wide between curbs on a 4-in. concrete foundation, with a 1½-in. sand cushion and cement-grout filler mixed 1 to 1.

NEW TYPE OF HILLSIDE BRICK—A notable departure from former standard practice has been made in putting a wire-cut-lug hillside brick pavement on Christie St. This is a new type of brick (described in ENGINEERING NEWS, Mar. 15, 1914), combining the distinctive features of the ordinary wire-cut-lug brick—lugs, square edges, and beveled ends—with two transverse grooves, about 3 in. apart, on the wearing surface, designed to give horses a foothold on steep grades.

The bricks are laid longitudinally with the street. Joints are broken on each brick so that instead of extending in lines across the entire width of the street, as in the case with ordinary hillside brick, each groove is no longer than the width of the brick. This affords shoe-calks opportunity to get a grip almost anywhere. However, as the grooves are broken at short intervals, broad tires bridge them on alternate courses of brick and roll over the pavement without experiencing an appreciable jolt.

Christie St. has a grade of 6¼%. It was paved 46 ft. wide for a distance of 700 ft., with a double-course granite-block header at the base of the hill. The street curves on the grade, and the brick (running lengthwise with the street) were laid in such a manner that the courses conformed to and ran parallel to the curvature of the curb (Fig. 1). The effect is extremely attractive, as will be seen by an examination of the accompanying view, which

*Information from F. A. Churchill, of the Dunn Wire-Cut-Lug Brick Co., Conneaut, Ohio.

FIG. 1. CHRISTIE ST., TORONTO, ONT., PAVED WITH WIRE-CUT-LUG HILLSIDE BRICK, LAID IN COURSES PARALLEL TO CURB

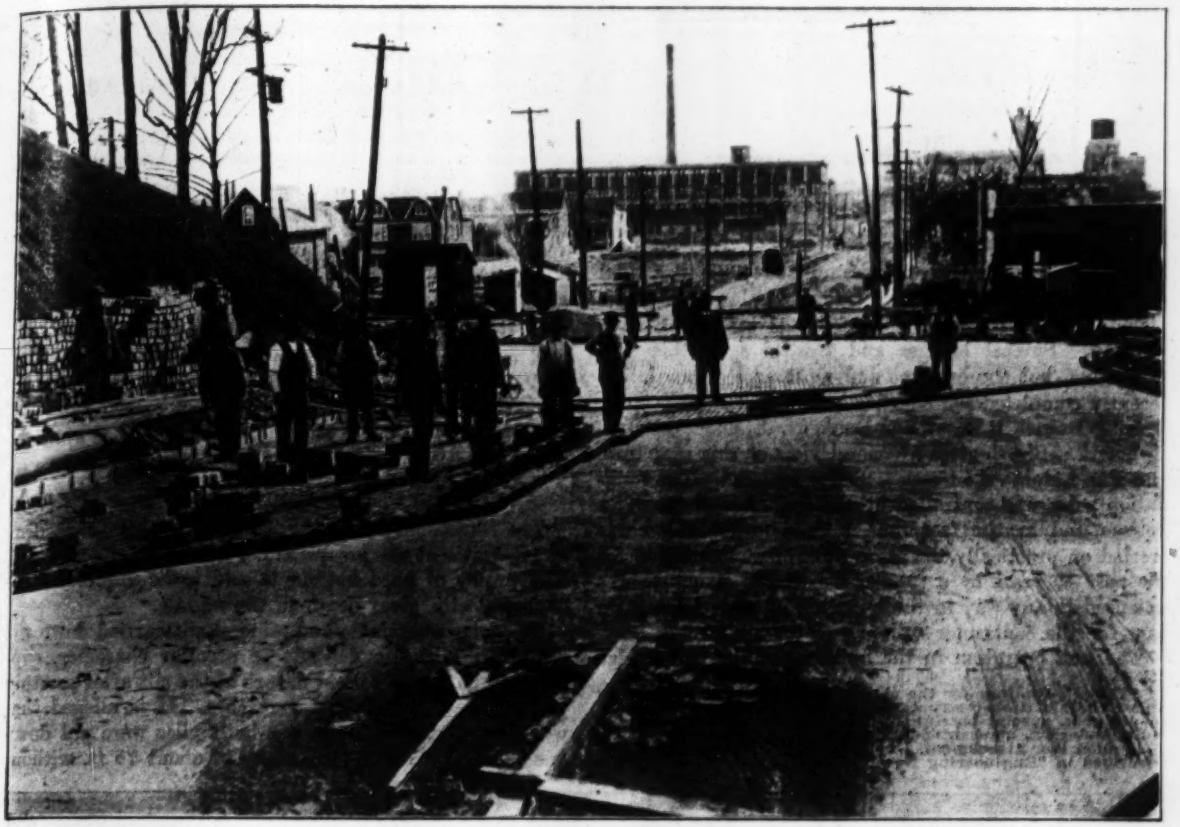


FIG. 2. CHRISTIE ST. PAVEMENT; HILLSIDE BRICK LAID ON A LEVEL STREET INTERSECTION

was taken before the bricks were rolled or the pavement was cleaned off.

None of the hillside brick was laid in courses at right angles to the curb, but they were laid obliquely across the street (Fig. 2), a method necessitated by laying the brick longitudinally in the direction of the length of the street. The pavement has a 6-in. concrete foundation and a 1½-in. sand bed, with cement-grout filler mixed 1 to 1.

GROUTING—The mixing of the grout for both pavements was done by hand. The grout was stirred continuously until it was scooped out with shovels and poured into the joints of the pavement. The grout box differed from grout boxes in common use in the States. It was a rectangular box made of planking, mounted upon two wheels about 12 in. in diameter and fitted with two 6-in. legs and two handles similar to wheelbarrow handles at the rear. The bottom joints of the box inside were finished with a triangular molding to prevent grout collecting in the angles. The box could be trundled from place to place very easily, and the wheels were so placed that the box could easily be tipped to collect the grout in the lower end. No grout was dumped. All was scooped and poured, a method which assures filling the joints.

Grouting was begun at the foot of the grade, as otherwise the thin grout would have flowed down the longitudinal joints and overflowed the lower part of the pavement. Small quantities of grout by the shovelful were poured at a time, and the surplus was quickly brushed forward up the grade. The final course of grout was squeegeed until the surface of the joints was full, flush with the pavement, care being taken to keep the joints full until the setting begun.

After the final course of filler began to set, the transverse grooves in the brick were brushed out with wire brooms. The brushing was not really necessary, as the grout in the grooves wears out under the impact of horses' shoe-calks, but the process made the grooves serviceable at once.

PERSONNEL—The City of Toronto is constructing its vitrified brick pavements by day labor. The work is being done by the Department of Works, under the direct supervision of M. A. Stewart, Assistant Engineer of Roadways, and W. Barber, Superintendent of Construction. W. C. Perkins, Chief Engineer of the inspection department of the Dunn Wire-Cut-Lug Brick Co., of Conneaut, Ohio, assisted the local engineers in an advisory capacity in constructing the Merton St. pavement.

Utilization of Water for Power, Wachusett Reservoir—During the three years since the hydro-electric plant at the Wachusett Reservoir of the Boston Metropolitan Water-Works has been in service (see "Engineering News," Feb. 15, 1912, p. 294, and Aug. 14, 1913, p. 297), 79.9, 83.2 and 98.4% respectively of the water drawn from storage has been used in generating power before entering the supply aqueduct. This shows a remarkable coördination of the requirements of the water-works and the power company (Connecticut River Transmission Co.) The plant is operated by employees of the Metropolitan Water Board, normal running time being confined to two shifts, though occasional demands from the power company require 24-hr. operation. Running time and rate of output are at all times subject to the orders of the chief dispatcher of the power company provided it does not interfere with requirements for water.

Field and Office

A Floating-Pile Foundation in Silt

The peculiar silt bed of the Shrewsbury River, a tidal inlet in the New Jersey beach region, has always made the placing of satisfactory bridge footings something of a problem. Several bridges and trestles span this arm of the sea, but the heaviest and most pretentious is the recently completed plate-girder bridge of the New York & Long Branch R.R., at Red Bank, N. J., about 1600 ft. in length. Fig. 1 gives a general view of this structure, and Fig. 2 shows the trestle which it replaced. The foundation work was controlled by the character of the river bottom and by the fact that, although the bridge was erected on practically the same right-of-way occupied for the past 40 years by a trestle, the timber structure was not used in any way in the handling of material or as a base for the contractor's plant.*

The first operation in the building of the new bridge was to knock down the west half of the old trestle, to provide space for the construction work to go forward. About 40 years ago the east half of this trestle was built as a single-track crossing, and some 8 years later a second track was added by erecting a duplicate trestle on the west side of the original structure, with bents lapping half way those of the older structure, but with common deck. Therefore, all that was necessary in cutting the old structure in half was to tear down one of the independent trestles; the second half was demolished after the west track was put in operation on the new structure.

Soil Conditions

The Shrewsbury is filling, being only about 1 ft. deep at low water at the present time, with a 3½-ft. tide rise. The profile of hard bottom is said to be approximately V-shape, with great depth in the middle.

The mixed vegetable and mineral silt carried down the river forms bottom deposits of peculiar character, supposed to be due to colloid nature of the silt after meeting the salt water of the lower reaches. It is alleged that when the first pile trestle was built piles were put down one back of the other to a depth of about 75 ft. without

*The pile footings for the new bridge were put down partly under the old timber structure. To do this it was necessary to design a special outrigger. This device was designed by John Anderson, superintendent for G. B. Spearin, contractor. This piledriver attachment, which did very efficient work, was described in "Engineering News," Dec. 24, 1914, p. 1267.

Fig. 1. General View of Completed Railway Bridge, Red Bank, N. J.

meeting serious resistance. The silt when lifted in a shovel clings in a mass, and when replaced in the water breaks up and sinks to the bottom, with little discoloration of the water. Piles can be pushed down very easily, but a day later can be withdrawn or driven further only with great difficulty or not at all. Even oyster stakes exhibit this behavior.

Under these circumstances there was doubt whether pile bearing could be obtained sufficient for a heavy steel

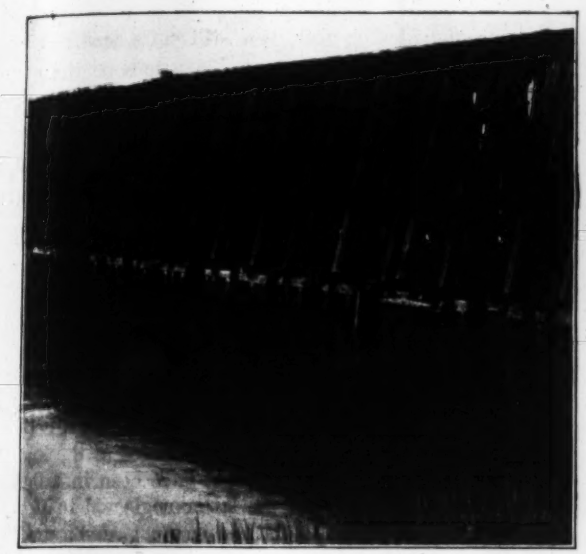


FIG. 2. VIEW OF 40-YR. OLD TRESTLE REPLACED BY NEW BRIDGE

bridge. To settle this doubt four piles were put down 55 ft. and loaded with 100 tons of rails. At the end of two weeks there was no settlement.

THE FOUNDATION

The new structure is carried on 80 concrete pedestals, each supported on twenty-eight 55-ft. wood piles. The

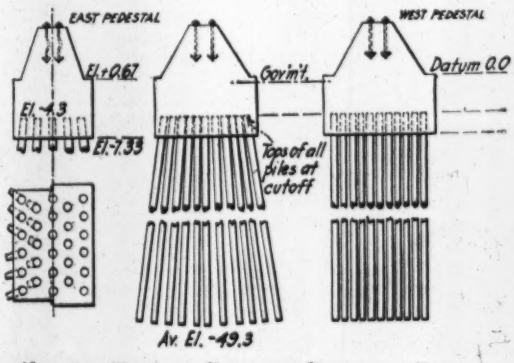


FIG. 3. TYPICAL PILE-AND-PEDESTAL FOOTING

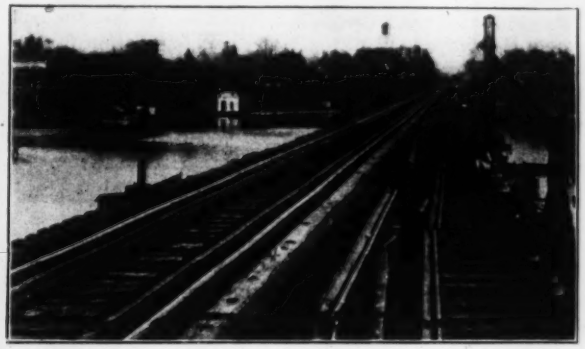
(The piles of the east pedestal were driven under the existing trestle and are therefore inclined.)

piles were all driven to a depth of 10 ft. below the bed of the river and coffer-dams, 11x14 ft., built, and the mud and silt excavated.

A layer of riprap was placed around the heads of the piles and 1:2:4 concrete for the pedestals placed on top. Each pedestal contains 65 cu.yd. of concrete and weighs approximately 130 tons.

The foundation work involved driving more than 2000 piles and placing 5000 cu.yd. of concrete. Traffic was maintained, during the entire progress of the work, over the single track of the old trestle. The work was carried on straight through the winter (September, 1913, to February, 1914, inclusive).

This foundation was built for the N. Y. & L. B. R.R., under the direction of G. V. Sneden, Engineer of Maintenance-of-Way (J. H. Fitzsimmons, Resident Engineer), by G. B. Spearin, contractor, New York City. John



DECK OF OLD TRESTLE DURING NEW CONSTRUCTION

(Traffic maintained on east track throughout construction. West half of trestle being taken down to make room for driving pile footings.)

Anderson was Superintendent for the contractor. The superstructure, consisting of twenty 25-ft. and twenty 50-ft. spans, and the approach spans, was furnished and erected by the American Bridge Co.

Motor Snowplow for Streets

The motor snowplow for street and park use shown in the accompanying cut is a special modification of the Bulley gasoline tractor, built by the Mercury Mfg. Co., of Chicago. The single steering wheel is removed, and is replaced by a V-plow. The plow has an angle of 60°, with 18-in. wings 8 ft. long, and is supported by a 12-in. wheel inside the nose and a 6-in. caster under the rear

TRACTOR CONVERTED INTO A MOTOR SNOWPLOW

end of each wing. The machine is steered by the small wheel in the nose of the plow. This is effected by means of a wire cable attached to the regular steering mechanism and passing around a horizontal sheave at the nose, geared to the spindle of the carrying wheel. In tests made in Washington Park, Chicago, the machine ran at 6 to 8 mi. per hr. through heavy frozen snow.

Renovating a Worn-Out Concrete Pavement*

The repair or covering of concrete pavements on city streets having car tracks in the center offers a more or less serious problem; for here the theory applied to concrete roads that the old concrete will make a good foundation for a wearing surface better adapted to changed traffic conditions does not hold, because the grade of the surface is fixed by the track rails. In other words, the concrete is from 4 to 6 in. too high for a foundation for any other type of city pavement unless the track is raised, which is seldom possible.

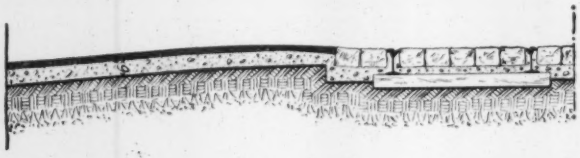


FIG. 1. CROSS-SECTION OF OLD CONCRETE PAVEMENT RESURFACED WITH 2 IN. OF BITULITHIC PAVEMENT

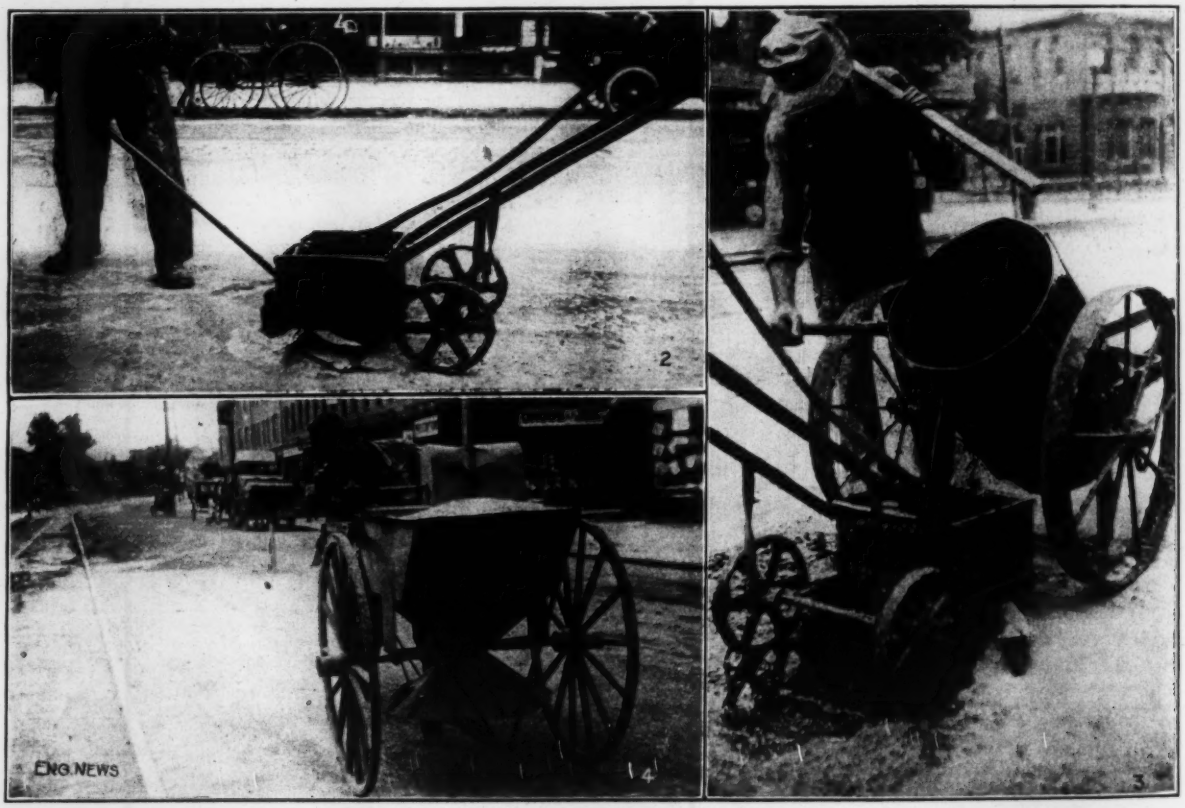
Such a problem came up during the past summer in Cambridge, Mass. An old concrete pavement on Massachusetts Ave. reached a condition where some form of covering, or its entire replacement, was imperative. For three years the 6-in. concrete pavement had been maintained by superficial applications of tar and bituminous oil, but holes had developed to such a degree that this was no longer an effective method.

The street originally had a rather steep crown. The railway track in the center had become depressed to about 2 in. below the surface of the concrete pavement. The situation was a difficult one to make satisfactory, as the street railway company did not feel like raising its tracks and it would have been very expensive to take off the top of the old concrete pavement, for parts of it, especially near the center of the street, were still quite hard.

A compromise plan was adopted; portions of the car track were raised where they had become depressed most. About an 18-in. wedge of the paving at the side of the track was removed as shown in Fig. 1, and the old concrete covered with approximately 2 in. of "bitulithic" pavement (a dense asphaltic concrete laid by Warren Bros. Co., Boston, Mass.), so that about 2 ft. 6 in. from the rail the grade was at least 2½ in. above the rail. From this point down to the gutter the crown varied from ¼ in. per foot to ¾ in. per foot. This made a crown or "roll" in the street between the tracks and the gutter. While this was not desirable, the appearance was not so unsatisfactory as at first thought.

The drainage on the tracks was taken care of by a good longitudinal grade and the water was collected at the lowest points. Here track drains should have been installed by the railway company, but the latter neglected to provide them, so at these points the water gathers until it overflows and reaches the gutter.

*From information furnished by L. M. Hastings, City Engineer of Cambridge, Mass., and G. H. Perkins, Superintendent of Refineries, Warren Bros. Co., Boston, Mass.



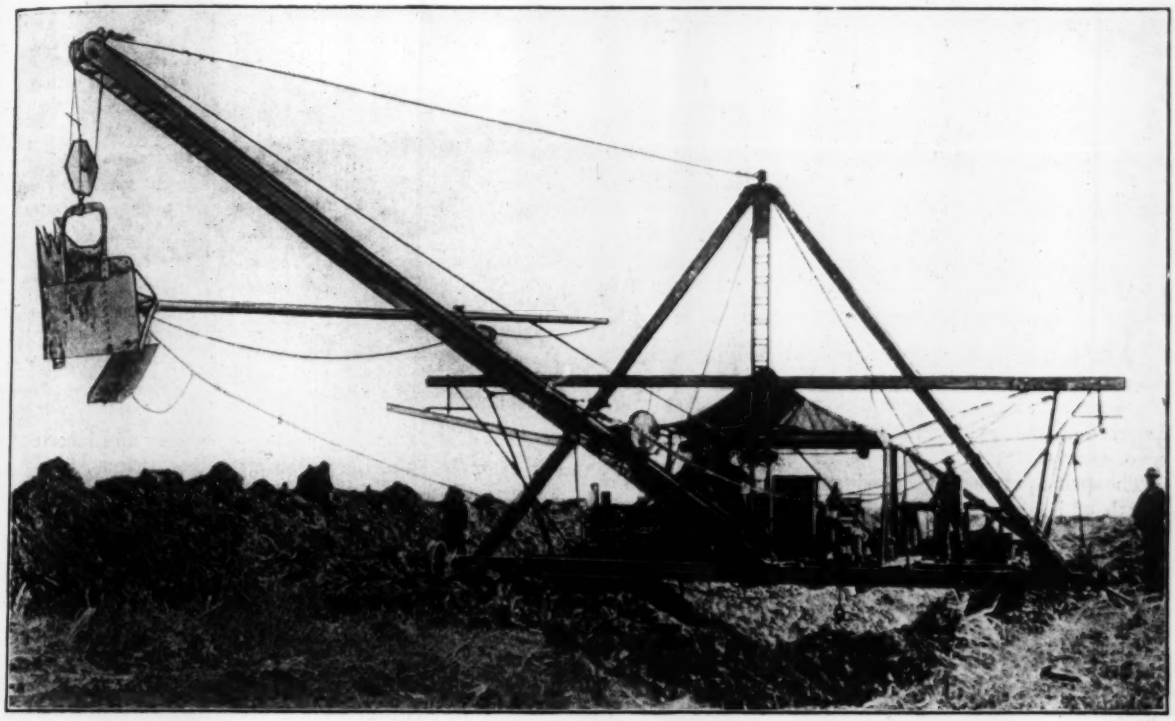
FIGS. 2, 3 AND 4. RESURFACING AN OLD CONCRETE PAVEMENT WITH 2 IN. OF BITULITHIC
(2 and 3, spreader for flush coat asphalt; 4, cart for spreading stone screenings on flush coat)

Oil-Engine Dipper Dredge

The dipper dredge shown in the accompanying cut is intended for excavating trenches and drainage or irrigation ditches, and is built by the Bay City Dredge Works, of Bay City, Mich. It is of the land type, being mounted on a platform which has I-beams spanning the excavation. It has a latticed steel mast and boom, and a timber A-frame. The boom is 30 to 40 ft. long, and carries a dipper of ½ yd. to 1 yd. capacity.

There are four operating cables: The hoisting cable, attached to the bail of the dipper; the backing cable, attached to the rear of the dipper; the boom-swinging cable (passing over a drum on each side), and the hauling cable. This last is attached to a bridle whose ends are hitched to the rails ahead of the machine. All the machinery is operated from a kerosene engine of 25 to 40 hp. Only three men are required, one to operate the dredge and the others to shift and adjust the sections of track on which the machine runs.

The machine travels on grooved wheels under each corner of the platform, and is so arranged that the width between wheels can be varied to suit the width of excavation. There are two wheels under each forward corner and one under each rear corner. On each side of the ditch is a single rail in sections 6 ft. long, each section having three wood ties or blocks about 3x12x24 in. The sections are connected loosely by two-bolt splice bars. As the machine moves forward the rear section of track is raised, carried forward and lowered into place by a traveling hoist which rides on a runway along the side of the machine and extending 5 ft. out beyond the forward and rear ends of the dredge frame.



DIPPER DREDGE FOR DITCH AND TRENCH WORK; OPERATED BY A KEROSENE ENGINE
(Bay City Dredge Works, Bay City, Mich., Builders)

Hauling Material on the North Side Reservoir, Pittsburgh*

The new North Side reservoir, commonly known as Cabbage Hill reservoir, of the Pittsburgh water-works, has 160,000,000 gal. capacity, with a water area of 17 acres and a depth of 38 ft. It was built by the cut-and-fill method, three sides being built of rolled embankment and the remaining side entirely in cut, surrounded by a reinforced-concrete retaining wall along a public highway. The reservoir is divided into east and west basins by a hollow reinforced-concrete dividing wall 18 ft. high, whose interior serves as conduit.

HANDLING MATERIALS WITH MOTOR TRUCKS—All the sand and gravel used in the construction of the reservoir was dug from the Allegheny River and transported in barges to a hoisting plant. The material was then taken from the barge in a clamshell bucket and dumped into an elevated storage bin containing compartments for coarse gravel, fine gravel and sand.

From this bin it was taken to the reservoir, a distance of 1¾ mi., by six 5-ton motor trucks, each truck making from 18 to 20 trips per day of 11 hr. A similar truck was used for hauling cement. Concreting was not started until June 17; 30,000 cu.yd. had been placed by Sept. 29. At that time five of the trucks worked 24 hr. a day and hauled something over 70,000 tons of material a distance of 1¾ mi., and the last ¾ mi. was up a 4 to 6% grade.

The economy of the motor truck was marked. It would have been impossible for teams to make more than

*Based on the paper "Construction Features of the North Side Reservoir," by E. E. Lanpher and J. S. Cole, and the discussion by S. L. Fuller, in the October "Proceedings" of the Engineers' Society of Western Pennsylvania.

six trips a day with a 2-cu.yd. wagon, which meant 11½ hr. It would have been impossible to complete the reservoir in one season had it not been for the use of the trucks, because it would have been impossible to have worked 150 teams in and out.

To Sept. 1 the cost of repair parts for the motor trucks was something like $15. This, of course, did not include a number of repair parts furnished by the maker under guaranty; but not over $100 was spent for repairs other than the general upkeep repairs ordinarily made. There was a night repair man and a day repair man to make any repairs necessary. From a fleet of seven trucks it was found necessary to hold one truck each day in the shops for overhauling.

At the reservoir, the supply bins and cement house were built on a southerly slope between the foundation of the secondary gate house and the Friday Ave. wall. These bins held approximately 400 cu.yd. of gravel, 200 cu.yd. of sand and 200 cu.yd. of coarse gravel. Storage was provided for two cars of cement in the cement house and one car on the platform. The sand and gravel were dumped from the trucks directly into the bins. The cement was dumped on the Friday Ave. platform and hand-handled to the chute leading to the cement house.

Analysis of Cost of Hauling on Country Roads

A method of analyzing the cost of hauling materials for construction work was given by T. R. Agg, Professor of Highway Engineering at Iowa State College, Ames, Iowa, in a paper read at the Good-Roads Congress at Chicago, Dec. 15-18, 1914.

The principal factors entering the problem are: (1) length of haul; (2) rate of travel; (3) time lost while loading at cars and unloading at the work; (4) time lost in travel on account of bad roads; (5) capacity of the outfit per trip; (6) cost of operation.

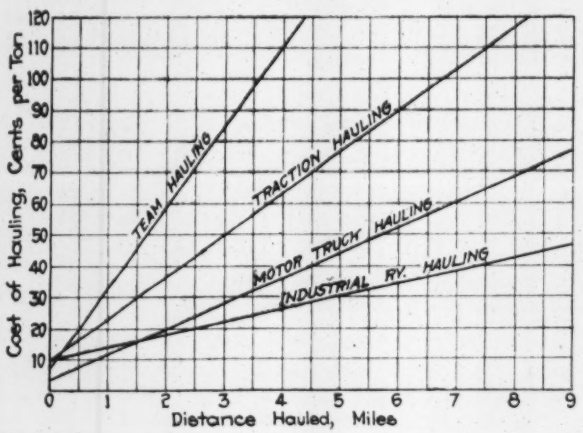


FIG. 1. DIAGRAM FOR ANALYZING THE COST OF DIFFERENT METHODS OF HAULING ROAD MATERIAL

Rates of speed are assumed based upon conditions, for example: 2½ mi. per hr. for teams, 3 mi. per hr. for traction outfits, and 10 mi. per hr. for motor trucks and industrial railways. The amount of time lost at cars depends upon the method of loading. Time lost at the cars is expensive, especially on short hauls, and should be eliminated as far as possible. The average loss of time per trip in loading and unloading is assumed, for an example, as follows: 18 min. with team hauling, 6 min. with motor trucks (loaded from bins or hoppers), 30 min. with traction outfits and industrial railways. Time lost due to the condition of the road varies with the season, the locality and the kind of road. It is greatest with the traction outfit, is about the the same for team and motor truck hauling, and is a negligible factor for the industrial railway (with locomotive). As to the capacity of the outfit per trip, equipment of the following capacities is in common use: wagons for team hauling, 2 tons; motor trucks, 5 tons; traction outfits, 15 tons; industrial railway trains, 20 tons.

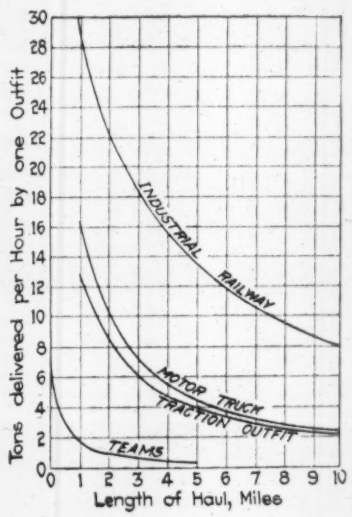


FIG. 2. CAPACITY DIAGRAM FOR ASSUMED CONDITIONS

The cost of operation of each of these outfits will vary with the skill of the superintendent and the operator, the kind of weather, and the nature of the road. It should include the following items: interest on investment, depreciation on outfit, maintenance of outfit, fuel, oil, supplies and labor cost. For example, take the following values: teams, 50c. per hour; motor truck, $2; traction outfit, $3 industrial railway $4.

Knowing the relation that exists between these various factors that enter into cost of hauling, the following equation may be used to show the cost per ton:

$$C = \frac{rd}{us} + \frac{Tr}{u}$$

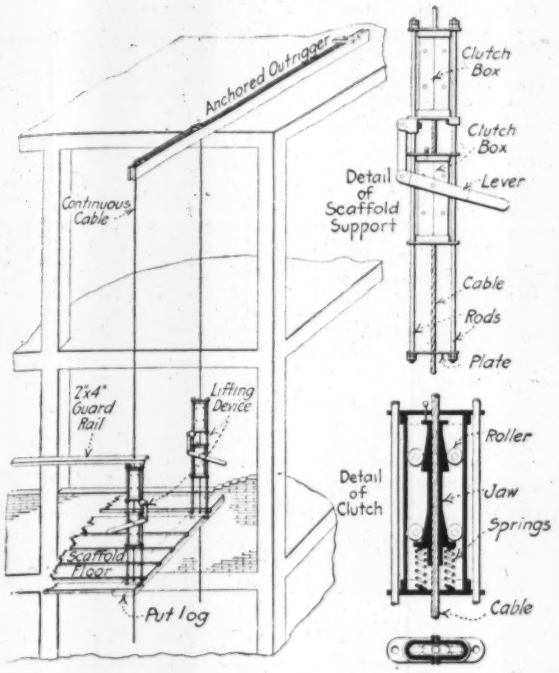
In this, C = cost per ton for a length of haul ($=\frac{1}{2}d$); d = distance in miles per round trip; u = tons hauled for trip; s = speed of vehicle, mi. per hr.; T = time lost loading and unloading; r = cost of operation in dollars per hour. Fig. 1 shows a curve drawn on the assumptions noted. Fig. 2 is a diagram of capacities based on the same assumptions.

The important thing is not the relative cost shown by the diagrams but the possibility of reducing to definite data the probable costs for any piece of work, thus obtaining a basis for determining which method to use.

A Suspended Scaffold for Building Construction

Suspended scaffolds are used extensively in erecting the exterior walls and trim of large buildings, and one construction of this kind is shown in the accompanying cut. One of its special features is that no drums are used on the platform or scaffold, the supporting apparatus being gripped to the cable by jaw clutches which have been tested to a load of 7270 lb.

At each point of support an outrigger beam is anchored to the roof (or an upper floor), this outrigger consisting of two planks with blocks spiked between them to support the two leads of the cable. Each lead passes through two clutch boxes (one above the other) which are secured to a pair of steel rods. A steel plate attached to the lower ends of the rods carries the putlog or cross-piece of the scaffold, on which rest the floor planks. At the upper end of



A Suspended Scaffold for Building Construction

the rods is secured a guard rail for the protection of the men on the scaffold.

Each clutch has jaws 10 in. long hung from steel rollers on short axles which have a shearing strength of 11,700 lb., or 93,600 lb. for each apparatus. The clutch is operated by a horizontal lever having a leverage of 8 : 1, and each stroke of the lever raises the machine 6 in. The friction and wear on the cables is said to be considerably less than when the cables are wound on drums. The cable hangs free from the outrigger, and the scaffold can be started from the ground and raised gradually to the top of the building without any temporary intermediate support and readjustment.

This device has been used on a number of structures, including the Golden Rule Building at St. Paul, Minn. It is built by the Eclipse Scaffolding Co., Omaha, Neb.

NOTES

A Computing-Machine Stunt—It is usually considered that the capacity of a computing machine in multiplication is limited by the number of places which can be made to appear on the multiplicand and multiplier dials. The statement is capable of some extension, in that a multiplication can be carried on so long as the sum of the places in multiplier and multiplicand does not exceed the sum of the places on the dials. Thus, it is possible to multiply 1,234,567 by 123,456,789 on a machine on which the dials show only eight figures in each term, as follows:

Set the upper (multiplicand) dials so that the number appears in the seven right-hand places and multiply by the eight right-hand places of the multiplier. The machine will then show:

0 1 2 3 4 5 6 7
2 3 4 5 6 7 8 9
0 0 2 8 9 5 8 9 7 7 6 2 5 3 6 3

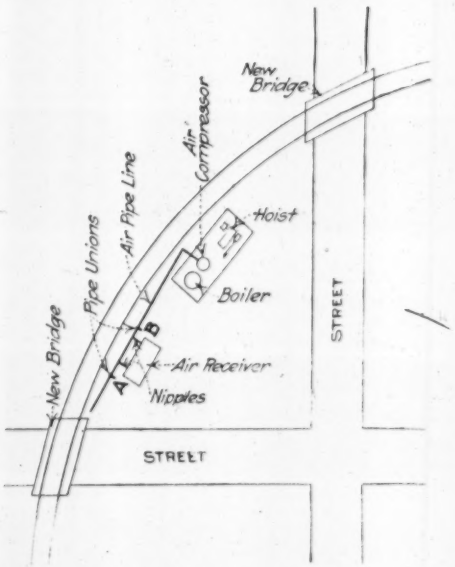
Clear the upper (multiplicand) dial; reset the multiplicand one figure to the left, which is equivalent to shifting the carriage (multiplier) dial one place to the right; then multiply by the left-hand and last figure of the multiplier. The dials then show:

1 2 3 4 5 6 7 0
3 3 4 5 6 7 8 9
0 1 5 2 4 1 5 6 7 7 6 2 5 3 6 3

The left-hand multiplier figure on the dial is the sum of the first two places of the multiplier.

Similarly, a problem of six by ten places may be worked on an eight-place machine by two resettings of the multiplicand.—Donald M. Liddell, Elizabeth, N. J.

Air Receiver Makes Trouble in a Riveting Outfit—A curious case of trouble in a riveting outfit, due to carelessness in arranging and locating the air plant in such a way as to avoid trouble from dust, is described by a correspondent. The work was the erection of several street-crossing railway bridges, where the air plant was laid out to supply several bridges some blocks apart. The riveting gangs were frequently delayed by dust, etc., clogging the ports and valves of the hammers. This was finally traced to two things, the absence of suitable screens at the compressor inlet—the operator thought such a refinement unnecessary in the field—and the unsuitable arrangement of the air receiver. The plant was placed about halfway between two bridges which were some



Riveting Plant Layout Which Caused Trouble from Dust

300 ft. apart. It consisted of boiler, hoist and winch and air compressor, and from here a 1½-in. pipe extended to both bridges. The air receiver was located near one of the bridges. It was cut into a branch or bypass of the line instead of into the main airline itself. Furthermore, on account of the lay of the ground, the main pipe was lower than the receiver, so that there could be no draining down into the receiver, but rather the reverse. As will be seen from the nature of the arrangement, the receiver had no action in the way of removing dust or moisture from the air, and since the railway traffic stirred up a considerable amount of dust alongside the roadbed, the unscreened compressor inlet allowed quantities of dust to get into the system and pass by the receiver to the hammers.

Vehicles on Public Roads in Pennsylvania Are Limited to 26,000 lb. weight, under an act of the state legislature. As with other legislative acts, there can be no certainty that this limitation will be maintained permanently, however, and therefore bridges on state highways are being designed to carry 17-ton trucks. The State Highway Department has advised township officials that no bridges, however remote the district, should be designed to carry less than 12 tons, and on all important thoroughfares or in reasonably well settled districts bridges should be designed for a 16-ton load.

Diagram for Use with a Solar Ephemeris—The accompanying diagram is designed to give the change in the sun's declination after Greenwich noon without interpolating in the ephemeris. It is similar to the one in "Engineering News," Mar. 6, 1913, p. 455, Fig. 5, for use in connection with Louis Ross' "Meridiograph," but is simplified and extended for universal use, and made independent of the hourly change variable. For example: Find declination of sun at 2:30 p.m., May 26, 1915, 90° West of Greenwich. The ephemeris gives the declination at Greenwich noon, N 20° 59.3′. On the upper diagram locate point a (90°, 2:30 p.m.); project vertically to Decl. 20° 59′, and read between horizontals, 3½′ = increase in declination since Greenwich noon. Hence, declination = 20° 59.3° + 3.5′ = N 21° 03′. This diagram with a one-page ephemeris is published by Louis Ross, San Francisco, Calif.

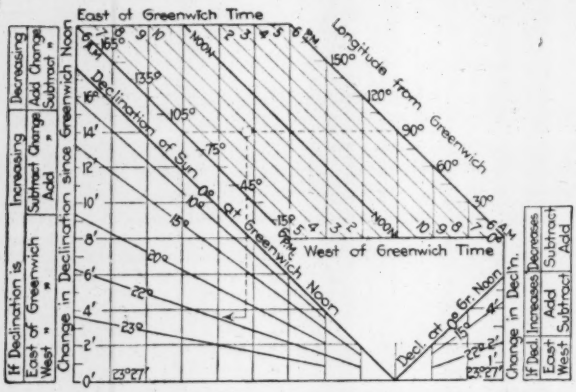


DIAGRAM FOR CHANGE IN SUN'S DECLINATION SINCE GREENWICH NOON

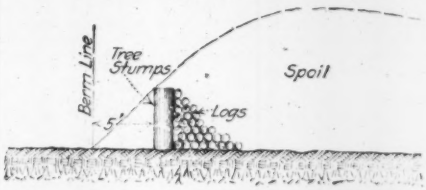
Some of the Joys of a Surveyor's Life are illustrated by the accompanying views and given in the following words of H. N. Bradstreet, transitman, office of the U. S. Surveyor General:

A survey party of the U. S. Public Land Survey moved camp on the last day of September to a point beside a lake on a mountain over 7000 ft. in elevation. It rained the night after pitching camp, and for two days and nights thereafter. Then it snowed just as steadily for two more days and nights. On the fifth day after the move, snow was waist deep, and still fell without any sign of intermission. The pack-horses were unable to get sufficient feed, and it was feared that they might take the trail down off the mountain of their own accord, so the chief of party, Hargraves Wood, thought it high time to break camp and pack the horses out. An insufficient number of horses to carry the entire camp necessitated the return in the snow the next day of the packer and two assistants, a distance of about 15 miles, and a climb of 4000 ft.

SURVEYING IN MONTANA, OCT. 1 TO 5, 1914

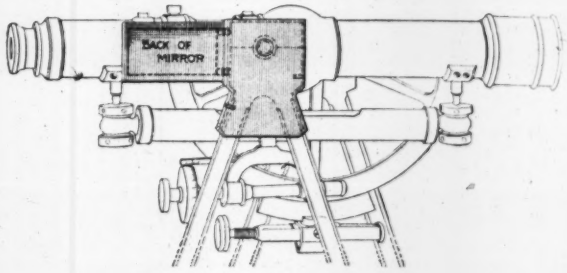
(Lake near Site of Camp; the Camp; Breaking Camp; Packing Out)

A Tree-Stump Retaining-Wall—In the construction of the Little River Drainage District in the southeastern section of Missouri, a novel method is being employed to retain the fill in the large spoil areas along the main drainage canal, and prevent the material from washing over the berm or into the channel. Trees are cut along a line about 5 ft. from the berm line and at a height of 4 or 5 ft. along the ground. The row of stumps forms a support for logs piled behind them, forming a timber banquette, as shown in the accompanying drawing. This forms a toe for the fill. As the district is heavily timbered there is no difficulty or increased expense in forming this banquette. The Chief Engineer is Wm. A. O'Brien, of Cape Girardeau, Mo.



TIMBER BANQUETTE TO RETAIN FILL ON SPOIL AREAS OF DRAINAGE DISTRICT

A Home Made Bubble Mirror for Transits is described by W. M. P. Shelton, Civil Engineer, of Burlington, Iowa, as follows: The device is a small recessed plate some 3 in. in height, fastened to the upper part of the right-hand telescope standard by two small buttons. At the near side is a small mirror attached by a hinge joint, which the observer turns to properly reflect the bubble. This attachment can be put on or taken off in a moment of time, requiring no change or disfiguring of the instrument. The weight is only 3 oz. The plate has raised edges equal to the thickness of the standards, so that the small buttons on top of the raised edges when turned, as shown, hold the attachment firmly to the transit. A recessed circle is made to accommodate the slightly projecting end of the telescope shaft.



HOME-MADE BUBBLE MIRROR FOR TRANSITS

A Method of Saving Money in Letting Pavement Contracts has been devised by City Engineer B. F. Miller, Jr., of Meadville, Penn. Last year the paving work was particularly expeditiously performed. There were 12 streets, aggregating over 4 miles in length, and these were grouped into 4 jobs known as A, B, C, D, care being taken that those streets were grouped together where physical conditions were practically similar. Some doubt was expressed as to the legality of this proceeding, but the work was finally let upon this basis, excellent legal advice being secured beforehand. It is estimated that an average saving of at least 10% was thus effected.

Editorials

Competitive Bids for Engineering Work

Nearly a year ago, in our issue of Mar. 12, 1914, we called attention to the stand taken by the Council of the Institution of Civil Engineers of Great Britain, condemning the growing custom of asking engineers to submit competitive bids for municipal engineering work. It appears that notwithstanding the warning circular sent out by the Council at that time, members of the Institution still submit bids in response to public advertisements. The Council, therefore, under date of Dec. 7, has issued a second circular to the membership, in which, after quoting the warning given a year ago, it says:

> The Council much regrets to learn that a number of corporate members of the Institution have lately responded to an advertisement of the Eastern Valley Joint Sewerage Board, inviting the submission of terms for certain professional engineering services.
>
> The Council now desires to state that response to an advertisement of the kind referred to is opposed to the best interests of the Institution and the engineering profession, and constitutes an action of professional misconduct, which renders the offender liable to expulsion from the Institution.

It will be of interest to see whether the Council will carry out its threat. The scramble for employment among engineers in Great Britain has been very severe for the past two or three years. There is little doubt that British municipalities advertising for engineering services can secure competent engineers outside of the membership of the Institution. Under these conditions it is not at all strange that some of the Institution members should engage in the competitive struggle; nor does it seem likely on the whole that even threats of expulsion from the Institution will be sufficient to stop them. What would seem to us a more hopeful procedure would be to provide means whereby a municipality might obtain the aid of the Institution in selecting the best engineer for a particular task. Lacking such aid, it is not strange that municipal authorities, feeling their own incompetence to judge of the quality of engineering services, fall back upon the price as a means of choosing between competitors.

The Hall Process of Aluminum Production

The recent death of Dr. Chas. M. Hall, inventor of the electrolytic process of aluminum production, calls to mind events in connection with the early history of that great invention.

In the early '80's the metal aluminum was little more than a laboratory curiosity. The only method then known for its commercial production was its reduction from aluminum chloride by metallic sodium, a process so expensive that the metal was nearly as costly as silver. Chemists the world over were searching for some cheap method of manufacturing aluminum, for it was known that in the form of clay, aluminum was by far the most widely distributed of the metals. In every college chemistry class, professors were wont to tell their students of this great unsolved chemical problem.

Chas. M. Hall was the son of an Ohio clergyman, and was taking a classical course in Oberlin College. He was a zealous student in chemistry, and his imagination was fired by the stories concerning the possibilities if some cheap method could be found of producing this wonderful metal from its abundant natural sources. While still engaged on his regular college work he spent every spare moment in chemical studies and experiments which eventually resulted in his great discovery. It was little short of miraculous that this young student in an obscure college, with only the meager facilities for experimental work obtainable in a remote country town, succeeded where the greatest chemists and scientific investigators, aided by the finest laboratory equipment in Europe and America, had failed.

The process by which Hall succeeded was to dissolve a pure aluminum oxide in a molten fluoride and then reduce the metal from the dissolved oxide by electrolysis. Hall's process would have been impossible of commercial operation at an earlier day, for the cheap production of electric current by power-driven generators was not achieved till the early '80's.

Having made his great invention, Hall made his way to Pittsburgh and visited the Pittsburgh Testing Laboratory, feeling confident that the chemists in that organization would be able to understand the importance of the success he had attained. The late Capt. Alfred E. Hunt, then President of the Pittsburgh Testing Laboratory, was a man always interested in new scientific developments. He at once saw the vast possibilities in the new invention and assisted the young inventor in organizing a company to exploit it. The writer well recalls Captain Hunt's coming into the office of ENGINEERING NEWS, where he was always a welcome guest, and telling the story of the remarkable new invention. Not long afterward the writer visited the crude works in the vicinity of Pittsburgh where the first commercial work with the Hall process was being carried on. In ENGINEERING NEWS of Nov. 8, 1890, will be found a view of the interior of this little plant showing the small rectangular pots in which the aluminum oxide was reduced.

The first commercial plant built by the Pittsburgh Reduction Co. had a capacity of producing 50 lb. of aluminum per day. At the end of 1890 an output of 375 lb. per day had been reached. Plans had been completed, however, for a much larger plant, which was shortly afterward built at Niagara Falls for an output of five tons per day, absorbing 13,000 hp. of electric energy. A plant was also completed in 1890 at Manchester, England, to operate the Hall process for supplying the foreign demand.

Prior to Hall's great invention, less than 30 years ago, the total annual production of aluminum was only about 5500 lb. By 1900 the aluminum production of the

United States alone was over 7,000,000 lb. In 1913 the production of the United States had increased to 65,000,000 lb., while the world's production was in the neighborhood of 173,000,000 lb. No other single industry in the world absorbs so large an amount of hydro-electric power as aluminum production. About 18 hp.-hr. are required for the dissociation of one pound of metallic aluminum from its oxide, and to this theoretical minimum has to be added the necessary losses in the operation.

In an editorial discussion of the probable future cost of aluminum in ENGINEERING NEWS of 1890, after reviewing the various necessary elements in the cost, we said:

"It may reasonably be expected in a few years that aluminum will be produced at a cost as low as the present price of tin, and possibly as cheaply as copper."

While the production has always remained more or less of a monopoly, not only through the control of various patents, but through international combinations, the market price has been steadily reduced and the above prediction has been more than realized. Aluminum is already cheaper than tin; and bulk for bulk, it is even cheaper than copper. Among all the wonderful inventions of the nineteenth century, that made by the obscure Oberlin college student ranks among the foremost in the enormous industrial development which has grown out of it and the vast benefits which it has conferred on mankind.

The Cost of the New York Barge Canal

The new state administration in New York finds itself in a puzzling situation with respect to the State's great barge canal enterprise, begun more than a dozen years ago and now at last nearing completion. The money to pay for the canal's construction has thus far been provided by an issue of State bonds to the amount of $101,000,000, which was approved originally by a popular vote, as is necessary under the New York constitution. All but $5,000,000 of this fund has now been spent and contracts now in force will require some $6,500,000 to complete. Besides this, damage claims have been filed against the State on account of the canal's construction amounting to about $76,000,000 and $10,000,000 has actually been awarded for such damages.

Any estimate of the final cost of the canal made now is subject to uncertainty as to how much will be awarded by the courts on these damage claims. State Engineer Williams, on Jan. 24, gave out an estimate of $27,000,000 as the sum which will be required to complete the Erie, Oswego and Champlain canals, and stated that if funds are immediately provided, the Champlain canal and the Erie canal from the Hudson to Oswego can be finished and open for navigation in the spring of 1916.

It is, of course, obvious that the State, having expended so great an amount of money on the canal enterprise, which investment lies idle and unremunerative until the work is entirely finished, ought to complete the work and make it available to commerce at the earliest possible moment. But how can the funds be legally provided to pay for the coming season's work? The voters of the State might be asked to approve a new bond issue to provide the balance; but the election to pass upon the bonds could not be held until next November, under the constitution; and it is difficult to believe that the financial authorities of the State could legally borrow money in advance of a bond issue which might or might not be approved.

The legislature might be asked to approve the raising of a sum suggested as $10,000,000 by a direct tax, unpopular though such a measure would be in these times; but the revenue from such a tax would not be available for this season's work and it would be necessary for the State to borrow large sums in anticipation of the tax.

It is fair to say that while the public generally has been ignorant of the fact that many more millions would be required to complete the barge canal, the annual report of the retiring State Engineer, John A. Bensel, pointed out this fact a year ago. Mr. Bensel devoted a number of pages of his annual report to a statement of the reasons why the cost of the canal had run far ahead of the original estimate. These statements are of special interest to engineers at this time since it will inevitably be charged that the engineers who originally designed the canal were incompetent in that they did not accurately estimate its cost.

It should be apparent even to the most ignorant layman that if an engineer or anybody else designs a certain piece of work and makes estimates as to its cost and then that work is constructed on a plan materially different from that on which the original estimate was made, no fault should be found if the final cost is found to vary widely from the original estimate.

The original plan called for a 1000-ton barge canal, but changes were soon made by the Canal Board to accommodate barges of 2000 tons capacity. The width of the locks was increased from 28 ft. to 45 ft. The legislature ordered that movable bridges instead of fixed bridges should be built over the Oswego canal, and made some changes in the original barge-canal line. On the other hand, it must be admitted that in a number of items, the final cost of the work has far outrun the original estimate. By far the largest of these items is the damages to land and water powers. Claims have been filed against the State for damages to land amounting to $19,000,000, and to water powers amounting to $38,000,000, while railroad crossing claims aggregate $8,700,000 and contractors' damage claims, $7,000,000.

To what extent these damage claims are justified and to what extent they are attempts to extort money from the State, perhaps with the aid of political influence, is unknown. Lacking such knowledge it would be difficult to say how much criticism is deserved for the failure of the original estimators to provide sufficiently for such damages. Manifestly had a liberal estimate been included originally for such damages, it would have been an encouragement to claimants and might have even been construed as a justification.

As we have stated above, State Engineer Bensel's report a year ago stated plainly that large additional sums would be necessary to complete the barge-canal work. Were a state government run on the businesslike methods necessary in the conduct of a private corporation, heed would have been given to this warning at once. The barge canal situation would have been frankly faced and some plan would have been adopted for raising the money necessary to complete the work. Nothing was done, however, and consequently the State government finds itself in the situation briefly summarized above.

That the canal work must be pushed to completion without delay admits of no doubt. Whatever one's opinion as to the wisdom of undertaking the enterprise in the first place, since the State has already invested over a hundred million dollars in the enterprise it must carry it through.

It is of interest, however, to make a tentative summary of the total probable cost of the barge canal in the light of the most recent information. Adopting State Engineer Williams' tentative figure of $27,000,000 as the amount required to complete the Erie and Champlain canals, the total stands as follows:

Original bond issue	$101,000,000
Estimated additional	27,000,000
Cayuga and Seneca canals	7,000,000
Canal Terminals	19,000,000
Interest paid on canal bonds during construction of canal	16,000,000
Total	$170,000,000

The last item is one which is too often overlooked in estimating the cost of great public works; but it is as much an actual part of the cost as the hire of labor and the purchase of materials. The taxpayers of the State are now paying about $4,000,000 a year interest on the bonds issued to build the canals. Until the canals are finished the State will receive no benefit in return for this outlay. There should be no question, therefore, as to the prompt provision of funds for completion.

The Late Thomas C. Keefer and the Plans for the Victoria Bridge at Montreal

In an obituary note of the late Thomas C. Keefer, a contemporary states that he prepared plans for the Victoria bridge. Those who recall that famous old structure across the St. Lawrence at Montreal would doubtless construe the above statement as meaning that Mr. Keefer was responsible for its design. It may be well, therefore, to review a chapter of engineering history known to few engineers of the present day.

In 1851 Thomas Keefer was employed by the Montreal & Kingston R.R. Co. (predecessor of the Grand Trunk Ry.), to study the problem of bridging the St. Lawrence at Montreal. Although then only 30 years of age, Mr. Keefer had already become one of the foremost of Canadian engineers. From previous work for the Canadian Government he was thoroughly familiar with the St. Lawrence River and the difficulties with ice conditions, etc., to be met in connection with its crossing. He prepared plans for a bridge with 300-ft. wooden truss spans, except the central span, for which a 400-ft. iron-truss structure was proposed. The bridge was to be carried on masonry piers, which were to be built inside timber-crib coffer-dams of special design. After the piers were completed, these timber cribs were to be left in place and on the upstream end of each crib was to be built an inclined plane to form an ice-breaker. The estimated cost of the entire structure was $1,600,000.

Admittedly, Mr. Keefer's spans were bold for the engineering facilities and knowledge of that day. The directors of the railway company hesitated to trust the design of so important a structure to home talent, and they rejected Mr. Keefer's plans. The way in which Robert Stephenson's design for a tubular bridge came to be adopted in its stead is related as follows in Smiles' "Life of Robert Stephenson":

> In 1852 Mr. A. M. Ross, who had superintended under Robert Stephenson the construction of the tubular bridge over the Conway in Wales, visited Canada and inspected the site of the proposed bridge at Montreal, when he readily arrived at the conclusion that a like structure was suitable for the crossing of the St. Lawrence. He returned to England to confer with Robert Stephenson on the subject, and the result was the plan of the Victoria bridge, of which Robert Stephenson was the designer and Mr. A. M. Ross the joint and resident engineer.

For the benefit of some of the younger members of the profession, it may be well to state that the Victoria bridge, like Stephenson's earlier notable structures, the Britannia bridge and the Conway bridge, was simply a rectangular box through which the trains ran. The top and bottom of the box formed the upper and lower chords and the sides the webs of what was practically a girder structure. It must be remembered that when Robert Stephenson invented this peculiar type of bridge, the engineering world as a whole was ignorant of anything but the rudiments of the stresses in girders and trusses. The railway itself was in its infancy and nothing was known as to the corrosive effect of the gases from locomotives upon exposed metal work.

In the early '50's, Robert Stephenson was at the pinnacle of his fame. His tubular bridges in England had been heralded to the public as a triumph of engineering skill, although there were even at that day in the engineering profession a few wise enough to criticize the design. It was not at all strange, however, that the directors of the Montreal & Kingston Ry., believing the task of bridging the St. Lawrence was one of unprecedented difficulty, decided to entrust the building of the bridge to an engineer of world-wide fame.

Mr. Stephenson visited Canada while the designs for the huge bridge were being completed, and it is stated that he rejected all the suggestions made by Mr. Keefer and other Canadian engineers. The piers of his structure were of massive masonry and were long held up to the profession as most remarkable examples of high-class stone work. While the bridge superstructure was 16 ft. in width, the piers were made 21 ft. wide at the bridge seat. Whether this was to secure a more stable structure against ice thrust or in foresight of the day when a new and heavier structure might replace the original, is uncertain.

The total cost of Stephenson's Victoria bridge was $7,500,000, a sum which in view of the low prices of labor and of all materials other than iron then prevailed would correspond to probably $12,000,000 at the present day. The heavy financial burden involved in the construction of this bridge nearly bankrupted the railway company.

Notwithstanding its enormous cost, and perhaps because of it, the Victoria bridge was hailed by the public and by a large proportion of the engineering profession as the eighth wonder of the world. But there were not wanting engineers, even at that day, who believed in that definition of an engineer (which had not then been formulated) as "a man who makes a dollar earn the most interest," and who understood that a truss bridge could have been built across the St. Lawrence in place of Stevenson's gigantic iron box for a small fraction of the cost.

By the time work on the Victoria bridge was actually under way, the Warren truss and Bollman truss had come into use, the Fink truss had been invented, the lattice girder had been applied to long spans and the Howe truss was in extensive use on American railways in spans up to 250 ft. The disadvantages of the tubular bridge

were not long in making themselves manifest. Passage through it had all the objectionable features of gas, smoke and darkness attendant upon traffic through a tunnel. The steam and sulphur gases confined inside the structure rapidly attacked the metal and corrosion went on apace. Perhaps the most serious feature of all was that those responsible for the safety of the bridge found it well nigh impossible to determine what was its margin of strength. Inspection of its interior was exceedingly difficult. As engineers became more familiar with the theory of stresses in girder structures, the defects in the design of the old tubular bridge became more evident.

Year by year the condition of the old structure was a matter of greater anxiety to the officials of the Grand Trunk Ry. It was necessary to keep a riveting gang constantly at work on the bridge the year round replacing rivets whose heads had popped off. Wrought-iron rivets had been used, of course, in the original construction, but their failure indicated the over-stressed condition of the structure.

There came a time when the Grand Trunk officers desired to fortify their judgment with the advice of some eminent consulting engineer. They called in the late Thomas C. Clarke, who was then far advanced in years, but who held a leading position among American bridge engineers. Mr. Clarke went into the bridge with a party of the Grand Trunk engineers and saw the terrific corrosion which its plates had suffered. Just then a freight train came through the bridge and Mr. Clarke ran as fast as he could from the center of the span to one of the piers and remained over it until the train had passed. His report, it is needless to say, was to the effect that the railroad company ought to replace the old bridge with a modern structure at the earliest possible moment. Such replacement was soon started.

It has seemed well to set down these facts not only to record an interesting and almost forgotten chapter of American engineering history, but in order that the professional record of the eminent Canadian engineer Thomas C. Keefer, might be free from the charge that he was in any degree responsible for the design of the old tubular bridge at Montreal.

Letters to the Editor

Street Signs for the Protection of New Pavements

Sir—It may interest your readers to know that in addition to the notice published in the article on "Protecting Newly Paved Streets in the City of Baltimore," ENGINEERING NEWS, Jan. 14, p. 55, we erect signs in every block notifying those interested and the public in general that the streets will be paved. These signs are of a red background with white letters, the idea being to make it as prominent as possible. They are erected on lamp posts, telegraph poles, telephone poles or trolley poles, whichever may be the most convenient.

In addition to the sign and the notice which is served on all property owners, we notify in writing all public service corporations and city departments which have structures under the surface of the street. We also insert an advertisement in four issues of two daily papers at least six weeks in advance of actual construction.

In this manner we have reduced the number of cuts in improved streets very materially. Of course, some are made, but in the vast majority of cases they are occasioned by leakage in water or gas pipes, in which case the street must be opened.

R. KEITH COMPTON,
Chairman and Consulting Engineer
Paving Commission.

Baltimore, Md., Jan. 15, 1915.

How the Problem, "What Is Gravel?" Might Be Solved

Sir—In answer to the question, "What is gravel?" in ENGINEERING NEWS of Nov. 19, 1914, p. 1029, two suggestions come to my mind, namely: Is not the answer dependent upon local geological conditions; and a disagreement between an engineer and a contractor?

In regard to the first thought, I will relate my experience of last spring, when I was asked to show several contractors a certain gravel (?) bank in connection with its optional use in concrete construction. Among the remarks were the following: "This is as good gravel as I ever saw for concrete;" another said, "This is good sand, but where is there any gravel?"

These men brought with them, perhaps unconsciously, definitions used locally, plus or minus the personal equation. Quite possibly the second man came from a seaport town, where everything gritty up to 3 ft. in diameter is classed as "sands of the sea."

Not only among contractors but among engineers and laymen does one find both the local and personal equations existing. Perhaps what is suggested to the average man when "gravel" is mentioned is a mass of rock fragments, ground by nature, varying in size from $\frac{1}{32}$ to 6 in. (90% under 3 in.) and generally containing sand (sand being generally understood to mean relatively fine, naturally or mechanically screened gravel).

It is perhaps impossible to define an ideal gravel without knowledge of local geological formations, class and magnitude of construction and other widely varying conditions. To illustrate: As a general rule gravel which is the hardest to excavate from the bank is the best for road work and the poorest for concrete.

The question, "What is gravel?" is also suggestive of "What is rock?" which has been the cause of innumerable disputes between engineers and contractors throughout contract history.

Rock is generally defined in specifications as "all material where blasting, barring or wedging is necessary for the excavation thereof"; and the engineer is left to de-

...le the necessity. Is this fair to the contractor? It would seem that our large engineering societies could ... no better work than to compile a comprehensive *specification dictionary,* defining therein all materials used in ...nstruction work and giving such tests, sizes and definitions as would be necessary to determine, without partiality, the dividing line between materials and of different classes of the same material, giving each class a distinguishing letter or number for reference.

The engineer could then write such specifications as were locally necessary and refer to such materials as were suitable to his work. For example, materials used shall conform to the following: Gravel *No. 7* concrete *class A;* excavation (rock) *class 5,* etc. General specifications of the American Society . . . . .

This would take a great burden from the contractor who, if conscientious, must now learn a new set of indefinite definitions for practically every new job.

Such a dictionary would continue a good work already begun by the American Society for Testing Materials in its year book, and might well become to the engineer and contractor what the "General Statutes" are to the lawyer. Who will undertake this work for us and put in large red letters the answers to "What is gravel?" and "What is rock?"

SELDEN P. SEARS, Assistant Engineer,
Hartford (Conn.) Water-Works.

New Hartford, Conn., Nov. 25, 1914.

Reinforced-Concrete Slab Floors with Staggered Columns

Sir—Referring to an article that appeared in your publication of Dec. 17, 1914, on page 1214, dealing with a new flat-slab reinforced-concrete floor construction, the writer begs to state that this form of construction is nothing that is especially new, as he designed and built flat slabs with staggered columns, as described in this article, for the American League baseball grandstand, Boston, Mass., in 1911.

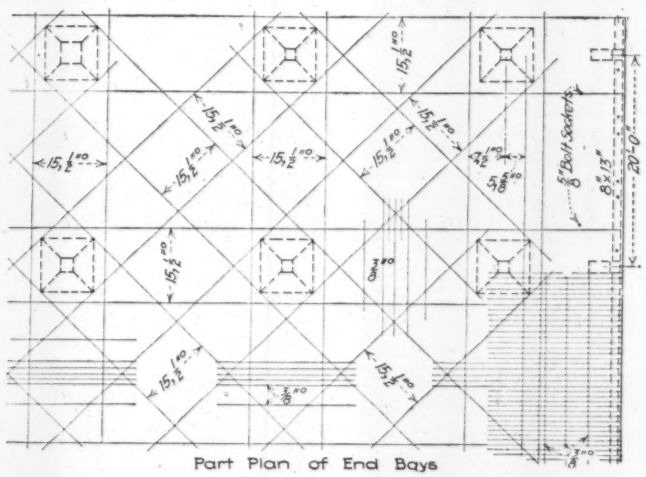
A part plan and section sketch of this grandstand is reproduced herewith.

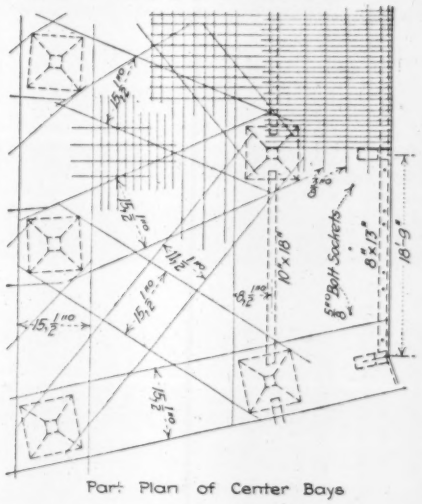
The writer does not wish to have any controversy in regard to this patent, but wishes to state that he is at liberty to use this form of slab construction as occasion calls for it, and in doing so, he will not feel that he is infringing on any patent as his knowledge of this form of construction extends further back than the date of the Morrow patent, June 17, 1913.

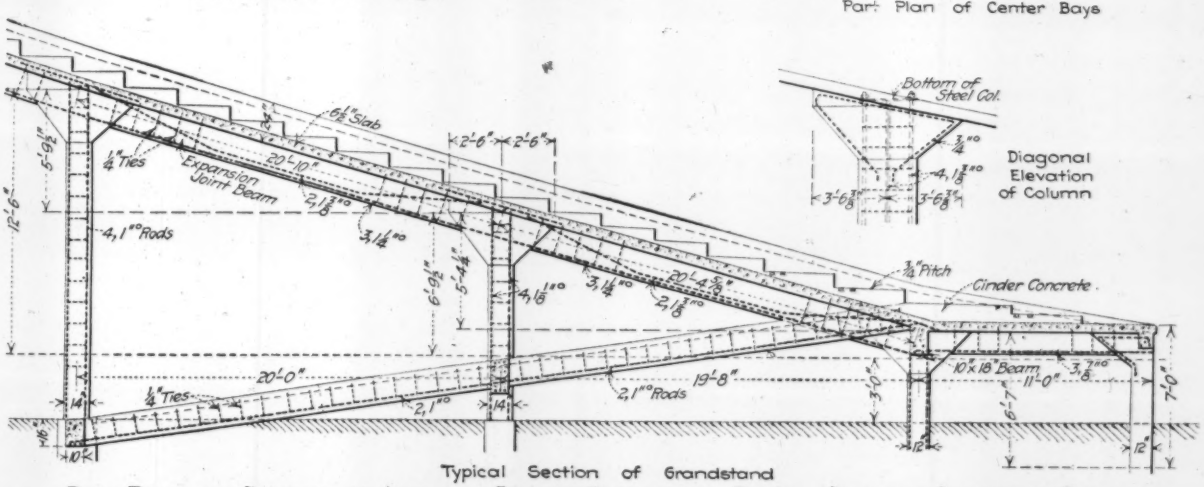
L. KOPCZYNSKI.

Cambridgeport, Mass., Dec. 23, 1914.

Large Grain Elevator for Baltimore—The Western Maryland Ry. has prepared plans for a $650,000 grain elevator to be erected at its Baltimore terminal. The elevator is expected to have a capacity for handling 12,000,000 bu. of grain annually, with a dead-load capacity of 850,000 bu.







PART PLAN AND SECTIONS OF AMERICAN LEAGUE GRANDSTAND, BOSTON, SHOWING STAGGERED COLUMNS

Annual Meeting of the Indiana Engineering Society

The annual meeting was held at the Severin Hotel, Indianapolis, Jan. 21, 23, with President Albert Smith (Purdue University) in the chair, and a registered attendance of about 100 members and visitors.

The subject of "Flood Protection in Indiana" was dealt with by Prof. Wm. K. Hatt (Purdue University), who is chief engineer of the Indiana Flood Commission appointed by the Governor in the spring of 1914. He discussed the flood conditions and characteristics, and estimated the losses in the flood of March, 1913, at $19,000,000 (for Indiana). Studies in flood protection are hampered by the small progress made in scientific studies of the streams. The problems to be dealt with in the commission's investigation are as follows: 1, capacity of bridge openings; 2, design of flood protection works; 3, methods of financing such works; 4, control of watersheds; 5, maintenance of the works when constructed; 6, the relation of the federal government to such works.

The new Indiana law does not provide for state-aid, but permits the incorporation of flood-protection districts, such districts and their plans being subject to the approval of the Commission. Prof. R. L. Sackett (Purdue University) presented a paper on "Decisions in Flood Drainage Cases."

The Committee on Sewerage pointed to the inequitable method of levying assessments on property for payment for sewers. A sewer on one street may cost twice as much as that on another street, and while a 12-in. pipe may suffice in one case another may require a 36-in. sewer. But the benefits to abutting property are the same in either case, and the area over which the cost of each sewer is assessed may be the same. The committee also called attention to the common neglect of sewage disposal plants installed at small towns and at institutions. It therefore submitted general rules for the operation of such plants. The construction of concrete roads was dealt with by C. D. Franks (Chicago), and the road problem of Indiana was reviewed by C. A. Kenyon (State Highway Commissioner). There were other papers dealing with roads and bridges.

A paper on "The Strength of Concrete as Influenced by the Duration of Mixing," by H. H. Schofield (Purdue University), discussed the results of tests. These showed very little difference in strength of concrete mixed ½ min. and 2 to 3 min., but there was a marked increase in strength for concrete mixed 8 to 10 min. A paper on "Uses and Abuses of Portland Cement," by J. E. Cassidy, referred to failures and unsatisfactory work in concrete for roads and buildings, resulting from ignorance or carelessness and due to lack of competent supervision. He presented the conclusion that "Concrete failures can be eliminated entirely when the work is designed by competent engineers and architects and carried out under competent superintendence."

While much has been done in standardising the design of steel framing for buildings, every building has some features that call for special design, and such features were discussed briefly in a paper on "Special Details in Reinforced Concrete and Steel Construction," by Louis W. Bruck (Indianapolis).

One group of papers dealt with matters of rates and valuation. One by H. A. Garman (Chief Engineer of the Indiana Public Service Commission), presented a simple method of computing a rate which will be fair and reasonable to both consumers and investors, many of the present rates being too complicated for the consumer to understand. In Indiana, the rate evils as discovered by the Commission are not so much rates that are unreasonably high, but rather rates that are grossly discriminatory. A paper by A. R. Holliday (Indianapolis) dealt with the training requisite for a valuation engineer, which should cover law and economics. Both papers agreed that in arriving at the value of a utility, the item of intangible values is usually the stumbling block. The "Analysis of Unit Cost" was the subject of another paper, by W. J. Huddle (Madison, Wis.).

Another considerable group of papers related to mechanical engineering. One by D. D. Ewing (Purdue University) on "The Accuracy of Watt-Hour Meters" compared the accuracy required by public-utility commissions with that which may be expected of first-class meters, and it suggested certain modifications of the commission's rules. A paper on "The Efficiency Movement in Machine Shops," by A. E. Ahara (Dodge Mfg. Co.) was discussed from the view of the theorist and the practical shop superintendent, and the author referred to the migratory habits of workmen in this country as a serious item in the problem of efficient management. In a shop having about 400 men, 200 remained steadily, while to keep up the remainder of the force about 800 different men were employed during the year. "The Relation of the Cost Department to Factory Organization" was the subject of a paper by C. H. Scovell (Boston), and M. W. Mix (Dodge Mfg. Co.) had a paper on "The Engineer as a Business Man." The recent tendencies in the design of internal-combustion engines were discussed by Hubert S. Watson (Lafayette).

A proposed bill was submitted for a State Board of Examining Engineers to consist of three civil engineers (following three different branches of the profession) to examine and license engineers. Another bill provides for city civil engineers, and specifies their duties and salaries. These were presented by A. P. Melton (Gary). Reference was made to the wide authority given to county surveyors on matters relating to drainage, roads and bridges, while no adequate qualifications are required for men holding these positions. One special session was held as a surveyor's meeting.

Annual Meeting of the American Wood Preservers Association

The remarkable development of the wood-preserving industry in various lines during recent years has been accompanied by a rapid growth of this association, which is very noticeable to those who have attended its meetings from year to year. The 11th annual convention, held at the Congress Hotel, Chicago, Jan. 19 to 21, had an exceptionally large attendance, and the variety of subjects discussed indicated the wide range of application for treated timber.

Preservatives and Preservative Treatment

The mixing of coal-tar with creosote has been practiced for some years, but the value of the mixture is a subject

of controversy. On the one hand it is claimed to be simply an adulteration of the creosote, while on the other hand it has been advocated as meritorious in itself and applicable in some cases where the higher cost of creosote oil alone would not be warranted. A specification for such a mixture, to enable a purchaser to define just what is wanted and will be accepted, was submitted in a paper by H. Von Schrenk and A. L. Kammerer, and gave rise to a discussion which covered the two opposite points of view noted above. The paper objected to the use of water-gas tar in creosote oil, when its presence is kept secret.

The report of the Committee on Specifications for the Treatment of Timber also brought up this subject in a suggestion that the use of the high-grade oil is not always economically necessary or desirable. In the case of ties, it would be uneconomical to use a treatment which would enable the wood to resist decay for a longer period than it would resist destruction by abrasion and mechanical wear. As to the trade names of such mixtures, the Committee on Plant Operation presented the opinion that the term creosote should not be applied to them.

The treatment of piling to resist the attacks of wood borers in sea water was discussed by E. S. Christian. He advocated 16 lb. of creosote oil per cu.ft., on account of the difficulty of now obtaining such oil having more than 35% of naphthalene, which is the main preservative element. In the same connection was a paper by L. F. Schackell, dealing with experiments made to determine the relative value of different oils in poisoning wood-borers which might attack the exposed timber. This indicated that while the naphthalene is a preventive against decay it has little effect upon the borers, the poisonous or toxic effect being in the tar acids and diminishing in creosotes of the higher boiling points.

The economic advantages of treating the structural timber used in mill and factory construction were strongly emphasized in a paper by F. J. Hoxie, dealing particularly with the peculiar conditions favorable to decay by both dry rot and wet rot. This opens up practically a new field for treated timber; we publish below some notes from the paper.

The heat conductivity of wood is a matter of importance in relation to preservative treatment, and some experiments in this direction were described by George M. Hunt (Forest Products Laboratory). The interior of the ties never attained the full temperature of the heating medium, and with 20 lb. steam pressure the time required for the interior to reach 212° F. varied from 2¾ to 5 hours, averaging 4⅓ hours. Seasoned ties heated more rapidly and showed less checking than green ties. The economical use of steam at treating plants was dealt with by A. M. Lockett, who considered that managers usually give more attention to maximum production than to economical utilization of steam.

The creosoting of Douglas fir was dealt with in a paper by H. E. Horrocks, who referred to the extensive use of this timber on the Pacific coast for paving, piles, wood-stave pipe, etc. On the other hand, it was stated the timber is not well adapted for treatment, and that its strength is likely to be affected.

Wood-Block Paving

The report of the Committee on Wood-Block Paving reviewed the history of such paving in the United States, and gave in tabular form the amount, kind, age and condition of the paving in a number of cities. A paper by Frank W. Cherrington showed that the laboratory analysis of sample blocks is not an effective or accurate method of determining the degree of value of the treatment. The wood structure is so complex that even blocks from the same plank may differ from each other, and show different degrees of penetration or absorption. When blocks appear white when cut, this is probably due to their being incapable of taking the oil, the wood pores being full of resin. With some 30,000 blocks treated at one time, it is futile to select a few samples for analysis and to judge of the entire lot by the results of such analysis.

The bleeding and swelling of paving blocks was dealt with by Clyde H. Teesdale, who gave the results of laboratory tests and experimental paving. It is thought probable the cause for such behavior is in the method of treatment. In this paper also the tar-creosote mixtures were referred to and the opinion was presented that they tend to retard swelling but will not prevent it, while they greatly retard the penetration. The statements in the paper were controverted very strongly by one speaker, but as his remarks were considered somewhat of an attack on the work of the Forest Products Laboratory, he was not permitted to complete his discussion.

Railway Ties

A method for determining the annual charges for ties was presented by Harrington Emerson and T. T. Bower. This led to some discussion as to whether simple or compound interest should be used in the calculation, and even whether any interest at all should be taken into account. The basis of this last argument was that a railway does not set aside a special fund for tie renewals or track maintenance, but pays for the work and material out of current funds. On this basis, the annual cost is represented by the cost of the tie in the track (including labor) divided by the number of years of its life.

A paper on "Air Seasoning of Ties," by A. H. Noyes, pointed out that in view of the decreasing supply of hard woods, the increasing use of soft-wood ties is a necessity. There is an abundant supply of such ties, and more attention should be given to the methods of handling and utilizing them. A paper by F. J. Angier (B. & O. R.R.) discussed the value of sill ties, or the bottom ties of the stacks piled in the yard for seasoning. If untreated these are liable to decay and damage and cannot be considered first-class material. They may be treated or replaced with concrete sills, the former being considered the more economical practice. A paper by J. H. Waterman (C., B. & Q. R.R.) gave details of the satisfactory results of red-oak ties treated with zinc-chloride.

Treated Timber for Factory Construction

The use of timber in mill and factory construction will continue undoubtedly for a very considerable period, and the protection and preservation of such timber is a matter of economic importance. Fire protection or rather resistance to fire is provided by heavy timbers and the approved mill-construction type of framing. Resistance to decay due to the attacks of fungus growths is another side of the question. Such resistance may be provided by a suitable preservative treatment of the timber, and it ap-

pears that this may be a much less elaborate and costly process than is necessary for the treatment of railway ties and piles. It is essential that the treatment should in no way reduce the strength of the timber.

This subject was dealt with at the recent meeting of the American Wood Preservers' Association, in Chicago, in a paper by F. J. Hoxie, engineer and special inspector of the Associated Factory Mutual Fire Insurance Companies.

Comparatively few botanical varieties of timber are available for mill construction, and this simplifies the problem somewhat, since it means a reduction in the varieties of fungi to be dealt with. The question of the infection of timber is of the utmost importance, and Mr. Hoxie stated that the facility with which new and sound lumber can pick up infection is almost incredible.

As to the preservatives, he considered that coal-tar compounds are not generally adapted to factory construction, owing to the black, greasy surface which they leave, their somewhat disagreeable smell and chiefly the increased fire hazard. In a recent fire the Factory Mutual Fire Insurance Companies paid a loss of about $60,000 on a paper mill where a coal-tar compound had been used on the roof planks. With fires in mill buildings the closed rooms can retain the heat generated by the burning oil, rapidly raising the temperature to the ignition point of the wood, extending the fire and increasing the water and smoke damage to the contents.

Chloride of zinc and corrosive sublimate have been used to a limited extent. There is little information available as to their value for structural timber, but Mr. Hoxie considers the latter best adapted to the requirements, and his general conclusions may be summarized as follows:

For treatment of mill timber an inexpensive process which can be applied on the job after the timber is cut to final shape has many advantages. It is probable that a reasonably cheap and convenient process, such as with corrosive sublimate in an open tank, will satisfy all requirements if applied soon enough. Probably a light treatment at the sawmill and another after the timber is cut to shape and ready to be put in place in the mill frame will be found most serviceable.

The Selection of Deep Well Pumping Machinery

A discussion of the comparative merits of various types of pumping machinery for deep wells was given at the recent annual meeting of the Illinois Society of Engineers and Surveyors, by Douglas A. Graham, Principal Assistant Engineer with Dabney H. Maury, Monadnock Block, Chicago.

The three principal types of machinery available for deep-well pumping are, first, the air lift, second, reciprocating or plunger pumps, and, third, rotary pumps, including both turbine and propeller type. The rotary turbine pump is usually the most expensive in first cost and the air lift the cheapest, the reciprocating and propeller pumps coming in between the two. In efficiency, the plunger pump ranks first, the rotary pump second, while the air lift is generally a poor third. From the point of view of reliability, however, often of such great importance in connection with water-supply, the air lift, which has all its moving parts above ground and easily accessible for inspection and repairs is well in the lead, with the reciprocating pump second, and the rotary pump third.

Other conditions, however, must be considered in connection with the installation of pumps. For example, a turbine rotary pump could not be successfully used in a well smaller than 12 in. diameter. A crooked well, making necessary a bend in the rods of a plunger pump or the shafting of a rotary pump, is bound to cause breakdowns and repairs if such pumps are installed, while the air lift is admirably adapted to such places. The air lift is also well suited to water high in sulphuric acid or carrying large amounts of sand, both of which cause serious injury to rotary or reciprocating pumps.

Variations of water level in the well have an important relation to the service given by the pump; and it must be remembered that the water level drops rapidly as the rate of pumping increases. The air-lift pump requires submergence of the air pipe of about 60% to give best results. Air-lift installations should be thoroughly tested while the erecting force is on the ground by continuous heavy pumping to determine the minimum water level, so that the submergence of the pipe in the well can be increased if necessary. Many tests of old air-lift plants show efficiencies as low as 10%, partly due to changing water levels and partly to improvements in design. Manufacturers' guarantees on air-lift pumps at the present day are as high as 30% to 40%.

A plunger pump must have its barrel as low as the lowest water level to be expected or there will be liability of the pump sucking air with danger of breakage. The turbine pump has the same limitations as the plunger pump, and in addition its efficiency and capacity are at a maximum for a very limited range of head fluctuation. Some forms of rotary pumps are free from this objection.

The efficiency and reliability of any pumping plant may be greatly affected by the manner in which it is erected. Preferably a pump should be installed by its makers or their representatives who can be held responsible for the machinery and the manner in which it is placed. The air-lift pump is least likely to serious injury by careless or incompetent operators, although its efficiency under such conditions may fall off materially.

Inasmuch as the selection of the machinery to be used depends upon the character of the well, it is important to determine this in advance of the purchase of machinery. Unfortunately, this is not always easy. If the well is a new one, then departures from straightness in its bore can be determined and a test of the water level can be made if sufficient funds are available to pay for the necessary pumping tests. Pumping installations are most frequently made in the smaller towns and villages, where the engineer, if there is one, is generally closely limited in the expenditure permissible. Nevertheless, apparatus which will show the water level in a well should be a part of every well-pumping plant. Such apparatus costs but a few dollars, and the knowledge of a falling water level gained in advance may save the wrecking of costly machinery.

The Use of Creosoted Douglas Fir Paving Blocks is being promoted on the Pacific coast through a newly organized Association of Creosoting Companies of the Pacific Coast. A meeting was recently held in Seattle, and five creosoting companies joined the association. F. D. Beals, President of the St Helens Creosoting Co. is President of the Association.

American Society of Civil Engineers' Annual Meeting

Little other than routine business was transacted at the 62d annual meeting of the American Society of Civil Engineers held at the Society's house in New York on Jan. 20. The reports of the various special committees, most of them having already been published in the *Proceedings*, were read by title only and very little discussion took place. In a social way the meeting was as much of a success as ever, and there was an unusually large attendance (about 800), so that the capacity of the society house was taxed to its utmost.

REPORT OF THE BOARD OF DIRECTION—The increase in membership in the society during the past year was 406; there were on Jan. 1 a total of 7678 members in all grades. Only a little over one-half the 730 applicants were admitted.

The work of the society through its special committees has been extended, so that the number of committees is now ten. The traveling expenses of committee members for attendance at committee meetings is now paid by the society on the same basis as that allowed members of the Board of Direction in attending board meetings.

Financially the society continues to prosper to a marked degree. During the year the mortgage debt was reduced $20,000, and $10,000 more of New York City bonds were added to the reserve fund. The interest on the reserve fund is $1350 in excess of the interest on the mortgage.

PRIZE AWARDS—The Norman Medal was awarded to Caleb Mills Saville, Chief Engineer of the Board of Water Commissioners, of Hartford, Conn., for his paper, "Hydrology of the Panama Canal." The J. J. R. Croes Medal was awarded to J. B. Lippincott, Consulting Engineer, Los Angeles, Calif., for his paper "Tufa Cement as Manufactured and Used Upon the Los Angeles Aqueduct." The Thomas Fitch Rowland Prize was awarded to H. T. Cory, Consulting Engineer, San Francisco, Calif., for his paper, "Irrigation and River Control in the Colorado River Delta." The James Laurie Prize was awarded to Samuel Tobias Wagner, Assistant Engineer of the Philadelphia & Reading Ry., for his paper, "The Elevation of the Tracks of the Philadelphia, Germantown & Norristown R.R., Philadelphia, Penn." The Collingwood Prize for Juniors was awarded to John Stalker Longwell, Junior Engineer, U. S. Reclamation Service, for his share in the paper "Experiments on Weir Discharge." The Board of Direction has decided that nonmembers of the society are not eligible for prizes.

COMMITTEE REPORTS—In presenting the report of the Committee on the Compensation of Civil Engineers, Nelson P. Lewis, Chairman, stated that the report (see ENGINEERING NEWS, Jan. 7, 1915) was essentially a progress report and that the work of the committee would be extended to include an investigation of salaries received by engineers who are not members of the Society. The committee on concrete and reinforced concrete had no formal report to submit, nor were there any from the committees on engineering education and on public utility valuation. The Carnegie Foundation has at last taken up the investigation of engineering education, and the society committee now merely coöperates with the Foundation.

The Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, Robert A. Cummings, Chairman, made a progress report. The committee has divided its work into two main branches: (1) codification of present practice; (2) a study of the physical characteristics of soils in relation to engineering structures. Filing records of local practice has been begun; samples of soils have been collected and classified; soil-test methods have been adopted. The committee is coöperating with the U. S. Bureau of Standards and the U. S. Bureau of Mines in experiments and tests.

In presenting the report of the Committee on a National Water Law, F. H. Newell, Chairman, stated that progress had been made in what proves to be a very large undertaking; but he said that the work was of very great interest and importance to the engineering profession, because the investment of millions of dollars was being held up on account of the present unsatisfactory laws.

The Committee on Stresses in Railway Track, A. N. Talbot, Chairman, made a progress report, in which it was stated that the work was being done in coöperation with a similar committee of the American Railway Engineering Association. Instruments have been developed and a number of static tests made on track under the passage of heavy freight locomotives. Tests are now being made on ballast and rail joints.

Rules have been adopted by the Board of Direction governing the appointment of committees, their government and procedure. The committees are to continue from year to year with the same membership unless changes are made by the Board of Direction, which may remove any member who fails to take an active interest in the committee's work. The committees are furnished with funds for their work by authorization of the Board, but budgets must be presented annually.

ELECTION OF OFFICERS—The officers elected for 1915 are: President, Prof. Charles D. Marx, of Leland Stanford, Jr., University, California; Vice-Presidents, Daniel Bontecou, Consulting Engineer, Kansas City, Mo., and Clemens Herschel, Consulting Engineer, New York City; Treasurer, Lincoln Bush, New York City; directors, District No. 1, J. V. Davies, Consulting Engineer, New York City, and G. A. Harwood, Chief Engineer of the Electric Zone Improvements, New York Central & Hudson River R.R.; District No. 4, J. E. Greiner, Consulting Engineer, Baltimore, Md.; District No. 6, John F. Coleman, Consulting Engineer, New Orleans, La., and John B. Hawley, Consulting Engineer, Fort Worth, Tex.; District No. 7, Herbert S. Crocker, Consulting Engineer, Denver, Colo. The contest between Frederic Molitor and G. A. Harwood for election in District No. 1 resulted in a vote of 2192 to 1188 in favor of Mr. Harwood.

ANNUAL CONVENTION—The newly elected president did not make a formal address but took the occasion to urge the members of the society to support of the International Engineering Congress to be held at the Panama-Pacific Exposition in September, 1915. The annual convention of the society is to be held at San Francisco, Sept. 15 to 19, immediately preceding the congress. A special

train has been arranged for from New York to San Francisco.

Prof. Marx stated that 320 papers were expected and that at least 225 could be counted on. Some 325 societies had been invited to participate, and of these 230 have responded. There are now only 2261 subscribers to the congress, and of these 1598 are from the United States and its possessions; 649 of these are from the American Society of Civil Engineers. There are so far only 48 foreign subscribers—from Canada, Great Britain, France and Holland.

Resolutions—A resolution was unanimously passed that the society take requisite steps to be officially represented at the formal opening of the Panama Canal. A resolution was also passed that the proposed constitutional amendment redistricting the society to 13 geographical districts be sent out to letter ballot.

Discussion of Road Construction

The progress report of the Special Committee on Materials for Road Construction and on Standards for Their Test and Use, aroused considerable criticism, chiefly on definitions, which include rather lengthy statements on "brick pavement," "earth road," "sidewalk," and other terms, which some thought were self-explanatory. On the other hand, Eugene W. Stern, the newly appointed Chief of the Bureau of Highways, Borough of Manhattan, New York City, deplored the fact that the committee had confined its attention to bituminous road construction, and offered a resolution (which was not acted upon) that the committee enlarge the scope of its work and present a report on all road materials not later than January, 1916.

Clifford Richardson (Consulting Engineer, New York City) thought that the committee had neglected the work already done by individuals in the literature of bituminous road construction, and stoutly defended hand-mixing, which is condemned in the committee's report. Other men prominent in the field of asphalt chemistry differed widely with the committee on definitions, methods of tests, etc.; which gave convincing proof of the difficulty of the work before the committee.

Some of the principal points brought out in the discussion follow:

Sampling—There was a general agreement that the methods of taking test samples were very loose. Very different results may be had if the sample is taken from the material in the kettles, instead of from the material as it comes to the plant, as should be done.

Supervision—Too much stress cannot be put on experience and attention to small details in the construction of bituminous roads. James Owen (Consulting Engineer, Newark, N. J.) went so far as to say that proper mechanical manipulation of the materials was more important than scientific knowledge. Success lay more with the foreman in charge than with the engineer. He gave instances of the use of the same materials with widely different results. The interference of inexperienced inspectors is responsible for much bad work.

Crowns—High crowns for bituminous road surfaces were condemned by all. R. A. Meeker (State Highway Engineer of New Jersey) said that crowns of over ½ in. per ft. should never be used under any circumstances.

Edgings—The committee's recommendation of concrete or other type of edging on all bituminous pavements was condemned by Mr. Meeker as entirely wrong. The extra cost of such an edging, he stated, would far better be put into additional width of pavement. B. H. Wait (Division Engineer, New York State Highway Department) described a type of poured bituminous macadam, considerably cheaper than the pavement of the road proper, which was used successfully for edging. T. M. Ripley (Division Engineer, New York State Highway Department) considered plain macadam edgings, or shoulders, ample for the lighter traffic roads. Trouble with concrete and brick edgings was mentioned; the chief trouble was the forming of a rut along the outside edge. An instance was mentioned of the use of irregular stones, properly bedded to form a shallow wall along the edge of the pavement, flush with the surface and bonded into the pavement, which had proved both a cheap and a satisfactory edging.

Application of Bitumen—On no subject was there a greater variety of opinions than on the method of applying bitumens. Good pavements have been constructed by so many different methods that no general rules seem possible. A deep penetration leaving the wear to come on the stone seems desirable. Too much bitumen was generally admitted to be one of the causes of failure. The subject of pressure distributors was discussed. It was stated that a pressure of 30 to 40 lb. per sq.in. should be enough for any conditions, and that if it was not the trouble was with the nozzle. On the other hand, a pressure of 50 lb. per sq.in. was defended as a means of cleaning the stones ahead of the treatment and because the asphalt should be applied at the lowest possible temperature. For the maintenance of old pavements, W. H. Connell, Chief of the Bureau of Highways, Philadelphia, described the successful use of an asphalt cutback for surface painting.

It was agreed that it was a prime essential that the road surface be clean when the bitumen is applied, but as to its absolute dryness, much difference of opinion was expressed. Mr. Meeker prefers a surface slightly damp and clean to one bone-dry and dusty. The committee's recommendation is that surface be dry.

Waves, Causes and Cure—Waves were laid to various causes. The subject was brought up by T. Hugh Boorman (Consulting Engineer, New York City), who referred to the articles in Engineering News, July 16, 1914, describing the creeping of asphalt-block pavements on Broadway, New York, and Ocean Ave., Brooklyn. G. P. Hemstreet (Hastings Pavement Co., New York City) said the same trouble was often experienced with wood blocks and sometimes with brick; the cause, he said, was heavy, rapid, motor-truck traffic, which set up a vibration in the pavement; this with the forward crowding motion actually moves the blocks on their beds. Mr. Hemstreet also stated that the movement could be effectually stopped by placing at regular intervals rows of special blocks, each provided with a steel key, which is bedded in the mortar bed.

Waves in rolled bituminous surfaces are often caused by a lack of stability in the surface mixture due to the use of too much fine material or an improper grading, too much or too little rolling, according to some. The use of stone chips or coarse gravel for covering bituminous oil coatings is quite general and the use of sand is growing less general. Poor foundation and the use of too large-sized an aggregate were among the other assigned causes of waves. Mr. Meeker said stone over 2 in. in size should never be used.

The curing of waves in rolled bituminous pavements by the use of a special plow made by the Headley Good Roads Co., Philadelphia, was described in some detail. In the Borough of Richmond, New York City, the lumps were removed by heating the surface and tackling the bituminous concrete with picks and forks. On the leveled surface of the old road 2 in. of new mixture was placed and rolled.

FOUNDATIONS—The discussion of the necessary depth of the cement-concrete foundation aroused considerable interest, but brought no general consensus of opinion. Mr. Boorman would make the minimum depth 8 in. Mr. Hemstreet also favored heavier foundations, stating that 4 in., as is common practice on suburban streets, is entirely too little for the heavy motor-truck traffic which is constantly being developed.

Proposed Standard Tests of Bituminous Road Materials

The following is an outline of the proposed standard tests for tar and asphalt recommended by the Committee on Materials for Road Construction and on Standards for Their Test and Use, of the American Society of Civil Engineers.

These tests are described in detail in the 1914 progress report of the committee, published in the December *Proceedings* of the Society, and issued in booklet form by the Secretary. A report of the discussion of the committee's report is given on the preceding page.

TARS

Specific gravity at 25° C. (77° F.).
Flash point.
Solubility in CS_2 (carbon disulphide).
Consistency at 4° C. (39° F.), 25° C. (77° F.), 46° C. (115° F.) 98° C. (208° F.).
Melting point.
Loss on evaporation at 163° C. (325° F.).
  Consistency of residue at 4° C. (39° F.), 25° C. (77° F.), 46° C. (115° F.), 98° C. (208° F.).
  Melting point of residue.
Distillation.
  Consistency of residue at 4° C. (39° F.), 25° C. (77° F.), 46° C. (115° F.), 98° C. (208° F.).
  Melting point of residue.

ASPHALTIC MATERIALS

Specific gravity at 25° C. (77° F.).
Flash point.
Solubility in CS_2 (carbon disulphide).
Solubility of bitumen in CCl_4 (carbon tetrachloride).
Solubility of bitumen in petroleum naphtha.
  Character of residue on glass.
Consistency at 4° C. (39° F.), 25° C. (77° F.), 46° C. (115° F.), 98° C. (208° F.).
Melting point.
Ductility at 4° C. (39° F.) and 25° C. (77° F.).
Fixed carbon content.
Paraffin content.
Loss on evaporation at 163° C. (325° F.).
  Consistency of residue at 4° C. (39° F.), 25° C. (77° F.), 46° C. (115° F.).
  Melting point of residue.
  Ductility of residue at 4° C. (39° F.) and 25° C. (77° F.).

News of the Engineering World

An Alaskan River Opened To Commerce

Secretary of Commerce Redfield has just announced that a practicable navigable channel from Bering Sea into the mouth of the Kuskokwim River has been discovered by Captain Lukens, of the U. S. Coast and Geodetic Survey. This river is the second greatest in Alaska. It is 9 mi. wide at its mouth and navigable for over 600 mi. inland. The great submerged flats of its delta extend 100 mi. out to sea, and it was through this dangerous delta that the surveying steamer "Yukon" made the discovery of the channel, which hitherto had not been charted. It is expected that the newly discovered channel will make it possible for steamship companies to send vessels up into the Kuskokwim and thus initiate the development of the latent mining, fishing and agricultural resources of the region. In making the survey, Captain Lukens reports that he took 14,256 soundings, covering an area of over 100 sq.mi., in some instances locating soundings by observations on mountain peaks more than 60 mi. distant. The whole working season was confined to 83 days and in July alone 29½ of these days were lost on account of bad weather.

Plans are already being made at Seattle for the construction by different companies of two light-draft steamships designed especially for the navigation of the Kuskokwim. These ships will be ready at the opening of navigation next spring.

Proposed Commission-Manager Plan for Wilmington, Del.

A commission of five members, vested with all legislative powers, and a city manager to exercise all executive functions are leading provisions of a proposed new charter for Wilmington, Del., which has been nearly perfected for introduction in the Delaware legislature by a committee of the Wilmington Civic Association.

The commission would consist of five members elected biennially and serving at a salary of $1200 per year, less a deduction of $20 for each absence from a regular meeting of the commission. A mayor without veto power would be elected by the commissioners from their own number and would act as President of the Commission. Any commissioner might be removed from office for cause on the vote of the other commissioners. The commission would have power to create and appoint the members of such subordinate boards as they might see fit, but any such boards would be advisory and administrative in capacity only and their members would serve without pay.

The city manager would be appointed by the commission without regard to his political belief and would hold office during the pleasure of the board. He would have direct charge and control of all the departments and employees of the city, would appoint and remove all heads of departments and nearly all subordinate

officers and employees in the classified and the unclassified services, but all appointments and removals would be subject to the civil service provisions of the charter.

The Civil Service Board of three members would be appointed by the commissioners, and would in turn appoint a chief examiner who would also act as secretary. The unclassified service of the city would include all officers elected by the people, the city manager, heads of departments and divisions, members of appointed boards, and a few secretaries.

Municipal Ownership of Water-Works at Des Moines, Iowa

On Nov. 3, the voters for the third time within a year cast an actual majority of votes in favor of buying the property of the Des Moines Water Co. The legislative act authorizing the purchase provided that the proposition must be approved by an affirmative vote "as large as the majority of all votes cast at the last preceding municipal election." Such a majority was not obtained at either the first or the second election, and as regards the third election legal opinions differ as to whether or not the words "municipal election" as used in the act refer to any municipal election or to a general election. Besides the doubt as to the validity of the water-works bond vote of Nov. 3, this situation exists: Under a suit brought by the city to condemn the property of the Des Moines Water Co., a valuation of $2,302,522 was placed by the court on Apr. 1, 1912. The company and the city agreed to this valuation and appeared before the Federal District Court and asked and obtained an order fixing the valuation and also fixing the date on which the city should take over the works as within one year from Dec. 3, 1913. The city requested the Federal Circuit Court to extend the time for the purpose of the works until May. 1, 1915. This the court refused to do on Dec. 30. The foregoing statements are based on information from Chas. S. Denman, General Manager of the Des Moines Water Co. The present status of the municipal-ownership project is thus summed up by James R. Hanna, Mayor of Des Moines: "The voters have again voted to purchase the water plant and have voted the necessary bonds; but the company continues to litigate and we are now in the courts."

Electric Pumping in Baltimore Water-Supply

Since the beginning of the year steps have been taken for pumping the entire city water-supply of Baltimore by electric power. Studies made by the city and by the Baltimore Gas & Electric Co. show this to be the most economical method of pumping. A contract has been executed for the supply of energy to approximately 2500 hp. in motors for the pumping stations at Lake Montebello and Druid Hill Park. The former will be run by electricity as soon as ducts and cables can be laid; the latter will not be converted until later in the year. About 6,500,000 kw.-hr. per annum will be taken by these two plants when in normal operation.

The company hopes to see the service grow to a demand for 25,000 kw-hr.

Progress on New York State Highways

The report of John N. Carlisle, Commissioner of Highways of New York, for the year 1914 shows that the State Highway Department spent nearly $20,000,000 during the year. This brings the total expenditure out of the $100,000,000 bond issues of New York to about $65,000,000. Some 6300 miles of highways have been or are being improved; about 5700 miles remain to be improved. About $3,000,000 of the 1914 funds were furnished by local authorities.

An experiment in road maintenance was tried during the past year. Instead of the patrol system, which is used throughout the state, two divisions were organized into mobile repair gangs, each with a full equipment of road rollers, trucks, oilers, etc., and the work was handled as is section work in railway maintenance-of-way. The experiment gave highly satisfactory results and the Highway Commissioner recommends that the system be extended throughout the state.

A great economy has been effected in the purchase of all repair material by advertising for bids. In addition to the maintenance work done by the state's own forces, 162 contracts for repair of roads were let for $1,700,000. Large sums will be required for maintenance during the present year. A readjustment of motor vehicle fees on the basis of horsepower is suggested, and a mileage tax on motorbuses using the state highways.

Nothing has ever been done toward using the $75,000 appropriation for a convict paving-brick manufacturing plant, and the Highway Commissioner asks for the immediate utilization of the appropriation for a plant at the Elmira Reformatory.

New York City Sewage-Disposal Studies

The rearrangement of the sewerage system of the Borough of Manhattan, and other large sewerage and sewage-disposal problems affecting New York City as a whole, will be considered during 1915 by the new Bureau of Sewer Plan created in 1914 by the Board of Estimate and Apportionment. This bureau consists of the same members—namely, Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment, and the consulting engineers to the five borough presidents—that composed the Sewer Plan Commission, appointed in June, 1913.

Instead of reporting to the whole Board of Estimate and Apportionment, the Bureau of Sewer Plan will report to a standing committee on Sewer Plan of the Board of Estimate. The city budget of 1915 contains an item for a small office engineering staff serving under the Bureau of Sewer Plan. This staff will include a consulting sanitary engineer and assistant engineer, a draftsman, and a stenographer. When the Bureau of Sewer Plan was established, it was understood that there would be appointed to its office engineering staff one of the principal engineers engaged with the Metropolitan Sewerage Commission of New York City, which went out of office on July 1, 1914.

The standing committee of the Board of Estimate and Apportionment consists of the President of the Borough of Brooklyn as Chairman, together with the Mayor of New York and the President of the Board of Aldermen.

Philadelphia Rapid Transit Progress

The first definite step in the construction of the new subways and elevated railways in Philadelphia was taken on Jan. 21 when City Councils passed an ordinance authorizing A. Merritt Taylor, Director of the Department of City Transit, to carry out certain sewer reconstruction required by the proposed new downtown subways. This would indicate that Councils is favorable to the new schemes, which have been worked out during the past year by the Department, and will soon authorize the $30,000,000 increase of the city's indebtedness required for the new lines. The voters of the city will have finally to approve such action, and an effort is now being made to call a referendum some time toward the end of March.

A Fire in Salem, Mass., on Jan. 21, in the business district destroyed the Leavitt block and several buildings nearby and damaged the Hotel Essex. The fire lasted eight hours and aid from seven neighboring cities was summoned.

Continued Slides in Culebra Cut on the Panama Canal may prevent the large warships of the Atlantic fleet from passing through the canal in March to take part in the review at the Panama-Pacific Exposition. It is stated that the bottom of the canal has been forced up in places by the lateral pressure, as happened at times in the region of the worst slides before water was turned in. In case the battleships are not able to proceed through the Culebra Cut, the review will be held in Lake Gatun.

A Boiler Exploded on the U. S. Cruiser "San Diego" just after a four-hour speed test off Las Pas, Lower California, on Jan. 21, killing four men and injuring nine others. Rear-Admiral Howard, Commander of the Pacific fleet, reports as follows:

The "San Diego" completed her four-hour full-power trials and made 21.45 knots. Just at the completion of the trials a tube in No. 4 boiler ruptured because of low water. No endurance runs were attempted. A full investigation has been ordered.

The "San Diego"—the "California" until the construction of the new battleship of that name was commenced—is an armored cruiser of 13,680 tons displacement. She was completed in 1907. Press dispatches state that since 1905 there have been 11 boiler explosions in the United States navy, which killed a total of 100 men.

Panama Canal Tolls in December aggregated $411,895, the highest monthly record since the opening of the canal. The cargo tonnage was 446,415 tons, not including two lumber cargoes containing 5232 M. ft. Ninety-nine vessels passed through the canal during the month.

Moving Pictures in a "Safety First Campaign" are to be used by the Coal Mining Department of the Delaware, Lackawanna & Western R.R. A series of moving picture plays, illustrating possible accidents in the mines, is being prepared and will be exhibited in the villages in the colliery region.

The Water-Supply Project for Ottawa, Ont., outlined on p. 43 of our issue of Jan. 7, 1915, has received the unanimous approval of the city council and will be submitted to the Provincial Board of Health. The proposition is to continue the use of the Ottawa River, without filtration, but to build a new pumping station on Lemieux Island and to lay a conduit to the mainland on a bridge.

The Death Rate of New York City in 1914 was 13.4 per 1000 population, and the infant mortality rate was 95 per 1000 births within the year, each the lowest rate for the city ever recorded. Typhoid fever and diarrheal diseases of children under five years were among the causes of death which showed considerable decreases. The total number of deaths in 1914 was 74,803 and the total number of births was 149,647.

Award of the John Scott Medal—The City of Philadelphia, acting on the recommendation of the Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Charles Edward Guillaume, of Sevres, France, for his alloy "Invar," which has become so useful for secondary standards of length, pendulum rods, compensating devices for torsion pendulums and balance wheels, and other devices requiring a metal with practically no thermal expansion.

A Legal Decision Bearing on the Responsibility of an Engineer in charge of highway work was recently rendered in a New York State county court. The case arose out of the building of a state highway in which it was alleged that the concrete foundation was of such poor quality as to render the bituminous and brick pavements practically worthless. The division engineer in charge was indicted and tried for wilful neglect of duty as a public officer. While the concrete foundation was admittedly poor, it was proved to the satisfaction of the jury that it came within the specifications for second-class concrete, which permitted unwashed, bank-run gravel. The responsibility was accordingly shifted to the specifications and the division engineer was acquitted.

Applications for the Position of General Manager of Norwood, Mass., are desired by the Selectmen. The person appointed will be the administrative head of all departments of the town government and must be "specially fitted by education, training or experience to perform the duties of" the office, but need not be a resident of Norwood when appointed. By a recent act of the legislature, adopted by popular vote, the water, sewer, park and light boards and the office of tree warden of Norwood have been abolished. The executive duties of those boards will be exercised by the general manager, who will also make all repairs to the library and school buildings of the town and purchase all library and school supplies except books. The population of Norwood in 1910 was 8014.

An Association of Street Cleaning Officials is proposed as a result of the interest shown in the recent exhibition of street cleaning apparatus held in New York City under the auspices of the City Street Cleaning Department. At the time of the exhibition an informal conference was held to consider the advisability of forming a permanent association of street cleaning officials in the United States and Canada. The following committee was chosen to take such steps as it considered warranted in forming a permanent association: J. T. Fetherston, Chairman, New York; Richard T. Fox, Chicago; Gus Hanna, Cleveland, Ohio; Walter G. Leininger, Chicago, and G. B. Wilson, Toronto. This committee has sent out a circular letter asking for expressions of opinion on the formation of an association, and all interested are asked to communicate with J. T. Fetherston, Chief of the Department of Street Cleaning, New York City.

A Bill to Register Architects in New York was introduced in the Senate on Jan. 14 and referred to the Committee on Judiciary. The bill provides that every person, before being known as an architect, must secure a state certificate of his qualification to practice under that title. A board of examiners is provided for, to be appointed by the Regents of the University of New York. Candidates in order to take the examination before the board must have had an education equivalent to an approved high school course, and, in addition, such courses in mathematics, history and one modern language as are given in the first two years of a college course. The candidate must in addition have had five years' practical experience in an architect's office. Persons engaged in the practice of architecture when the law takes effect are given a certificate without an examination. A fee of $25 is fixed for the issue of a certificate, and practice without a certificate is made a misdemeanor punishable by fine or imprisonment.

Automobile Omnibuses have recently become so numerous in Pacific Coast cities that their competition is seriously affecting the profits of the street railway companies. In Los Angeles, it is claimed that the motor omnibuses have reduced the earnings of the street railway companies by a million dollars a year. At Seattle, Mayor Gill opposes any further extension of the municipal street railway system on the ground that the motor bus competition will make the city's investments in such lines unprofitable. There are said to be 450 motor omnibuses now running in Seattle, apparently without regulation by either state or municipal authority, although in the Eastern States the right of public service commissions to regulate motor bus service is generally recognized. Bills are being introduced in the Pacific Coast legislature regulating the running of motor omnibuses, and it is said that an attempt will be made to subject them to special taxation to cover the wear and tear on pavement due to the operation of the machines.

Safety from Fire Danger in the New York Subway operation is being investigated by the engineering staff of the Public Service Commission. According to a report by Alfred Craven, Chief Engineer, inquiries are being made into the complete separation of telephone and emergency alarm cables from all other cables, complete separation of the lighting circuit from all other cables, the installation of an independent outside telephone system, the installation of an emergency service from the New York Edison Co., an independent current supply to ventilating fan motors, the walling up of all openings from manholes and splicing chambers into the subway, and an increase in the capacity of the ventilating chambers. Clifton W. Wilder, electrical engineer, has recom-

mended that the emergency lighting system from storage batteries on each car be altered so that the batteries will be automatically charged to full capacity at all times. The batteries now used have to be removed from the cars for charging; and at the time of the recent accident, it was found that some of the batteries were exhausted.

The Appointment of Engineers on State Commissions has been recommended to the Governor of Idaho by a committee representing the Spokane members of the National engineering societies in the following letter:

The engineers residing in and around Spokane who are members of some one of the four premier national engineering societies, that is, of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining Engineers, believe that there is a well-founded tendency of late among state executives and legislative bodies, in the appointment of members of utility and other regulative commissions, to recognize that engineers are well fitted for such positions. Their training, education and experience render them more peculiarly qualified in dealing with the large economic, industrial and development questions incident to state government than any other body of trained men. As a consequence their services are requisitioned more and more for the betterment of efficiency, expedition and service.

We know that there are in Idaho many accomplished engineers. We therefore desire to call your attention to the preceding facts and to respectfully suggest that when you fill the present vacancy in the Public Service Commission of Idaho, you consider favorably the appointment of one of your engineers.

Long-Distance Telephone Conversation across the continent was inaugurated on Jan. 25, when Dr. Alexander Graham Bell, in New York, talked to his former associate, Thomas A. Watson, in San Francisco. Mr. Watson was associated with Dr. Bell in the invention of the telephone, and on Oct. 9, 1876, these two men held the first telephone conversation over a two-mile line between Boston and Cambridge, Mass. The opening of the new transcontinental telephone line was witnessed by a large party of guests who assembled in the Telephone Building in New York and at the telephone headquarters in San Francisco. Receivers were connected with the transmission line so that a large number could listen to the conversation. After talking through the modern instrument, Dr. Bell took up an exact duplicate of the original telephone transmitter which was made for him by Mr. Watson in 1875 (the original of which is preserved in the Smithsonian Institution in Washington), and spoke through this to Mr. Watson in San Francisco, and the conversation was transmitted perfectly. Following the conversation between the two inventors, Mayor Mitchel, of New York, and Mayor Rolph, of San Francisco. During these conversations, Theodore N. Vail, by conversations between President Wilson at Washington and President Moore, of the Panama-Pacific Exposition, in San Francisco. During these conversations, Theodore N. Vail, President of the American Telephone & Telegraph Co., who was at his winter home on Jekyll Island, Georgia, was connected with the transmission lines so as to overhear all the conversation that passed. Later in the day a circuit was established from Jekyll Island by way of Boston to San Francisco, over which Mr. Vail at Jekyll Island talked with Mr. Watson at San Francisco over a total length of wire of 4750 miles. The New York to San Francisco line will be open for commercial business on Mar. 1, the charge for a three-minute conversation being $20.70. In this transcontinental telephone circuit there are 6800 miles of copper weighing nearly 3000 tons.

ENGINEERING SCHOOLS

THE HARVARD-TECHNOLOGY COÖPERATION AGREEMENT, which was expected to result in great gains in efficiency to both institutions, is claimed to be invalid on account of certain provisions of the will of Gordon McKay. President Lowell, of Harvard, announces that steps will be taken to submit the question to the Supreme Court of the Commonwealth for a decision.

UNIVERSITY OF ILLINOIS—Four vacancies in the research scholarship of the Engineering Experiment Station at the University of Illinois are to be filled at the close of the current academic year. Ten such scholarships have been maintained by the University since 1907. Each carries an annual stipend of $500, and is open to graduates of approved American and foreign universities and technical schools. Appointments are made [illegible] must be accepted for two consecutive years, at the [illegible] of which time the master's degree may be granted. [illegible] more than half of the time of the fellows is required in connection with an assigned department, the remainder being available for graduate study. Appointments are made in March to take effect the following September, and are based on character, scholarship and promise of success in proposed study. Preference is given to applicants with practical engineering experience.

WASHINGTON UNIVERSITY—A beginning of university extension work has been made in St. Louis with evening courses in electrical engineering under the direction of the Dean of the School of Enginering, Prof. A. S. Langsdorf. Two courses have been offered, each including classroom, laboratory and home work. The first one covers the principles of direct- and alternating-current machinery and is given on two nights a week; it is open to men over 18 years of age having a knowledge of algebra, some experience with electrical machinery and the equivalent of a high-school course in physics. The second course offered covers general electrical-engineering practice and is given on two nights a week. It is intended for men over 18 years of age engaged in engineering pursuits but who have had no opportunity to obtain a technical education.

A special course in economics of public utilities has been arranged for students in engineering. J. E. Allison, formerly Chief Engineer of the St. Louis Public Service Commission, is to be the lecturer. The topics will include principles of regulation, the organization, financing and operation of corporations, valuation for taxation and rate making, etc. Seniors are required to take the course. Mr. Allison has established a fund, the income from which is to be used in prizes for competitive studies of utility problems.

PERSONALS

Mr. Cecil N. Haggart, Assoc. M. Am. Soc. C. E., Pittsburgh, Penn., has been appointed Bridge and Structural Engineer of the Lake Erie and Ohio River Canal Board.

Mr. Harry J. Goodale, for 12 years Assistant Superintendent of Public Works of Pittsfield, Mass., has been appointed Superintendent of Public Works of Attleboro, Mass.

Mr. A. L. Branson, formerly Superintendent of Construction of the Donald Smith Co., Kansas City, Mo., has been appointed Manager of the A. L. Branson Construction Co., Muscatine, Iowa.

Mr. T. Furukawa, Chief Civil Engineer of the Grand division of the Imperial Railways of Japan, is touring this country with the object of studying maintenance-of-way problems.

Mr. Clifford C. Potter, who for the past 13 years has been connected with the Detroit Graphite Co., in New York City, is now New York sales agent for the M. B. Suydam Co., of Pittsburgh, Penn.

Mr. B. F. Beckman, Superintendent of the Fort Smith & Western R.R. and the St. Louis, El Reno & Western Ry., has been made Engineer of those roads, with headquarters at Fort Smith, Ark.

Mr. James G. Donovan has been appointed Division Engineer, at Hazleton, Penn., of the Mahanoy & Hazleton division of the Lehigh Valley R.R. Co., to take the place of Mr. T. J. Burke, transferred.

Mr. David A. Wright, who has been connected for several years with the Yale & Towne Mfg. Co., New York, as District Manager in the West, has resigned and opened an office as a manufacturers' agent at 140 S. Dearborn St., Chicago, Ill.

Mr. J. F. Porterfield, General Superintendent, at New Orleans, La., of Southern lines of the Illinois Central R.R., has been appointed General Superintendent of Transportation, with headquarters at Chicago, Ill. Mr. Porterfield succeeds Mr. J. M. Daly.

Mr. James Riley, Electrical Engineer, and recently with the Engineering Department of the Missouri, Kansas & Texas R.R., has joined a partnership under the name of Riley & Hardman. The new firm will have offices at 2124 West Main St., Parsons, Kan.

Messrs. Frederick J. Shollar and Frank A. Hersh, Altoona, Penn., have dissolved partnership. The business of the firm will be continued by Frank A. Hersh and Herman R. Hersh, under the firm name of Hersh & Hersh, with offices in the Central Trust Bldg., Altoona.

Mr. E. P. Roberts, M. Am. Soc. M. E., has resigned as Smoke Commissioner of Cleveland, Ohio, and will open an office in Cleveland as Consulting Engineer, specializing in the valuation of public utilities, fuel economy and smoke abatement. The City Council recently reduced the salary of Smoke Commissioner from $3600 to $2400 per annum.

Dr. Robert H. Richards, Hon. M. Am. Inst. M. E., Professor Emeritus of Mining Engineering and Metallurgy of the Massachusetts Institute of Technology, has been awarded the gold medal of the Mining and Metallurgical Society of America, in appreciation of his development of ore dressing processes. The presentation of the medal will be made at the March meeting of the Society.

Dr. Edward Weston, President of the Weston Electrical Instrument Co. of Newark, N. J., was presented with the Perkin Medal by the Society of Chemical Industry on Jan. 22. The presentation took place at the Chemists Club, New York City, the presentation being made by Dr. Charles H. Chandler. Dr. Weston came to the United States from England in 1870, when only 20 years old, and his early work was in the field of chemistry. He was one of the pioneers in the development of the electric-lighting industry. His numerous inventions in the field of electrical measuring instruments have played an important part in the electrical field for the past 20 years.

OBITUARY

Nicoll Comstock, a pioneer contractor of Kansas City, Mo., died on Jan. 20, at the home of his son in that city. Mr. Comstock was born at Trumansburg, N. Y., in 1831. He went to Kansas City in 1881, entering into partnership with his uncle, Warren Halsey. He laid some of the first block pavement in Kansas City. After Mr. Halsey's death, several years ago, the firm was discontinued, and Mr. Comstock then became an inspector in the county highway engineer's office. Mr. Comstock was 83 years old and left two sons.

Davenant Rodger, a prominent Canadian civil engineer, died on Jan. 19, at Brooklyn, N. Y., in his 63d year. Col. Rodger was connected with the construction of the Canadian Pacific R.R. and the Cape Cod Canal, and was commissioned by the Canadian Government to observe the construction of the Croton aqueduct and the siphon under the Harlem River. He was for many years Chief Engineer of the Chilean Government. At the time of his death, Col. Rodger had been engaged as prospective chief engineer of an irrigation project on the Colorado River in Arizona.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN CONCRETE INSTITUTE.
Feb. 9-12. Convention at Chicago, Ill. Secy., E. E. Krauss, Harrison Bldg., Philadelphia, Penn.

CHICAGO CEMENT SHOW.
Feb. 10-17. At Chicago. Secy., J. P. Beck, Universal Portland Cement Co., Chicago.

AMERICAN CONCRETE PIPE ASSOCIATION.
Feb. 15-16. Annual convention at Chicago. Secy., E. S. Hanson, 538 South Clark St., Chicago, Ill.

IOWA ENGINEERING SOCIETY.
Feb. 17-19. Annual meeting; at Iowa City. Secy., S. M. Woodward, Iowa City, Iowa.

MINNESOTA SURVEYORS AND ENGINEERS SOCIETY.
Feb. 19-20. Annual meeting, at St. Paul, Minn. Secy., George H. Herrold, City Hall, St. Paul, Minn.

INDIANA SANITARY AND WATER SUPPLY ASSOCIATION.
Feb. 24, 25. Annual meeting at Indianapolis, Ind. Secy., Dr. W. F. King, State Board of Health, Indianapolis, Ind.

ILLINOIS WATER SUPPLY ASSOCIATION.
March 9-11. Annual convention at University of Illinois. Secy., Edward Barlow, Urbana, Ill.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.
Mar. 16-18. Annual meeting at Chicago, Ill. Secy., E. H. Fritch, 900 So. Michigan Ave., Chicago, Ill.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.
March 16-18. Annual convention at Chicago. Secy., E. H. Fritch, 900 So. Michigan Ave., Chicago.

Aëronautical Society of America—A joint conference on aviation under the auspices of the Aëronautical Society of America will be held in the Engineering Societies Building, New York City, Feb. 5 and 6.

Cornell Society of Civil Engineers—A feature of the tenth annual banquet, held at the Hotel McAlpin, New York, Jan. 22, was the presence of a considerable number of men not graduates of Cornell University. This was partly due to a general invitation, issued in pursuance of a new policy of making these banquets popular assemblages of college engineers, and partly to the presence of Prof. Charles D. Marx (Leland Stanford), the new president of the American Society of Civil Engineers, as guest of honor. Prof. George F. Swain (Harvard) was one of the principal speakers; he set forth some recent tendencies and some necessary improvements in technical education, especially concentration of facilities and effort, and the need for cultural education. Prof. Marx emphasized the desirability of making the engineer a strong member of the community. Speakers for Cornell were Prof. C. L. Crandall, Prof. A. W. Smith, Prof. H. N. Ogden, J. H. Edwards (American Bridge Co.) and trainer Jack Moakley. Lantern views showing completed and projected improvements at Cornell were shown by Mr. Edwards, one of the trustees. The largest projected works are a drill hall some 250x350 ft., and a large group of "residence halls." Among the invited guests were Allen Hazen, W. T. Donnelly and Robert Ridgway. The society is in flourishing condition, with 755 members. C. N. Green (Public Service Commission, New York City) is president, and E. A. Truran (419 Warburton Ave., Yonkers, N. Y.) is secretary.

Appliances and Materials

New Westinghouse Induction Motor

A new line of large continuous-service induction motors for driving pumps, blowers, compressors, hoists, etc., and requiring heavy starting torque, has been put out by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn. The rotor is coil wound and has slip rings for inserting starting resistance into the circuit. One of the chief characteristics is unusual mechanical strength; the frame is massive, the bearings and shafts are extra large, and the windings securely braced. The bearings rest on three machined seats, according to steel-mill practice. The bearing shell may be removed and replaced without taking off the lower half of the bearing bracket.

* * *

A Frostproofing for Concrete

The Lansing Co., Lansing, Mich., has just put on the market a product, known as "Lansing Frostproofing," to be used to retard the freezing of concrete during the setting period. Tests show that the material materially retards freezing and at the same time does not lower final strength. It is in the form of a fine white powder, the composition of which is not announced, and is to be added to the concrete in amounts of two to four pounds per batch. The extra cost per cubic yard is about 75c.

* * *

Electric Locomotive with Mercury-Arc Rectifier

It has been known that the Westinghouse Electric & Manufacturing Co., the Pennsylvania R.R. and the New Haven R.R. were conducting service trials with a motor car drawing 11,000-volt single-phase current from an overhead line and feeding the motors with 1200-volt direct-current power secured through a mercury-arc rectifier of the large-capacity type recently developed. A little preliminary information is now available, but the details of the system and final figures have not been made public since the equipment of the car is largely experimental as yet. The car is a combination baggage and passenger type furnished by the Pennsylvania R.R. and carries the following: A transformer, transforming the 11,000 volts single-phase to 1200; two single-phase rectifiers, one in reserve; four 250-hp. direct-current motors; a small motor-generator exciter set for starting the

rectifier; control apparatus, etc. The rectifier is a light steel cylinder of about 20 in. diameter and 36 in. high; the alternating-current (rectifier positive) electrodes enter the top through tight insulating bushings. The direct current is furnished to the motors by connecting them between the negative electrode (mercury) and a lead running to the middle of the transformer secondary. It is reported that the motors operate as well on the pulsating current as on steady. The drop through the rectifier is about 25 volts, regardless of the current drawn. At full load the power loss is about 18.75 kw. and the efficiency, therefore, is in the vicinity of 97%. The full apparatus, including transformer, rectifier, switch groups, etc., occupies about half the floor area of the baggage compartment.

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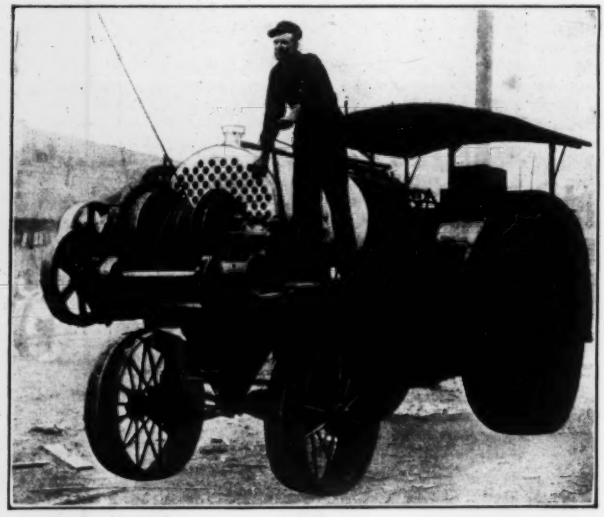
A Gasoline-Engine Tractor with Hoist

A gasoline-engine tractor-hoist combination intended for use in the erection of highway bridges and culverts, and in general contracting work, has recently been designed by the Minneapolis Steel & Machinery Co., of Minneapolis, Minn. As shown in the accompanying view, the hoist is mounted at the



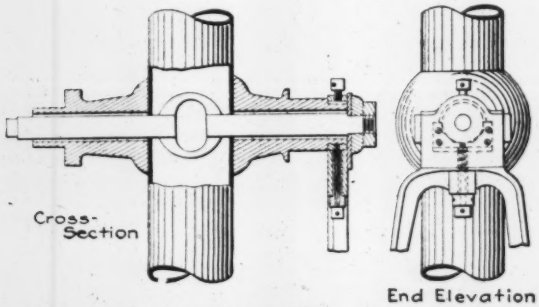
A Gasoline Traction Engine with Hoist

front and is belt driven from the engine transmission. A pull of 500 lb. can be exerted on the hoist line while winding at a speed of 105 ft. per min.

* * *

More Rigid Transit Standards

A device for increasing the rigidity of transit standards has been invented by Adolph Lietz, the instrument maker, of San Francisco. This "unifier," as is shown in the accompanying illustration, is simply a rod for tying the standards together at the top. The rod is inside the horizontal axis of the telescope and has a loophole in the center to permit a clear line of sight for any position of the telescope [except, apparently, when pointed to or near the zenith.—Editor.] The telescope, with its pivots resting in V-shaped bearings, revolves around the "unifier." The latter then forms a rigid and stable system with the standards which, in this instrument, are cast in one piece with the upper plate. Transits and theodolites with this improvement, made by the A. Lietz Co., San Francisco, have been tested in the field and found very satisfactory.—Otto Von Geldern, Consulting Engineer, San Francisco, Calif.



Lietz's "Unifier" for Transit Standards

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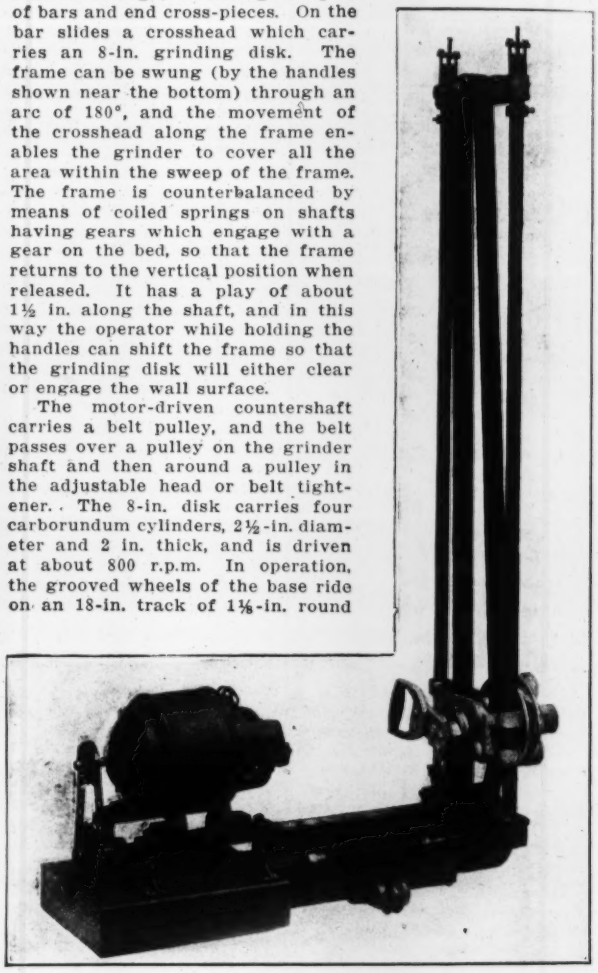
Wall-Surfacing Machine

The power-driven wall-surfacing machine shown in the accompanying illustration has been built by the American Floor Surfacing Machine Co., of Toledo, Ohio, and is now being introduced to replace hand work on certain styles of wainscoting finish, etc. It works on the same principle as the familiar floor-surfacing machines.

The bed carries a 2-hp. motor and has pivoted to it a frame 5 ft. high, consisting of a pair of bars and end cross-pieces. On the bar slides a crosshead which carries an 8-in. grinding disk. The frame can be swung (by the handles shown near the bottom) through an arc of 180°, and the movement of the crosshead along the frame enables the grinder to cover all the area within the sweep of the frame. The frame is counterbalanced by means of coiled springs on shafts having gears which engage with a gear on the bed, so that the frame returns to the vertical position when released. It has a play of about 1½ in. along the shaft, and in this way the operator while holding the handles can shift the frame so that the grinding disk will either clear or engage the wall surface.

The motor-driven countershaft carries a belt pulley, and the belt passes over a pulley on the grinder shaft and then around a pulley in the adjustable head or belt tightener. The 8-in. disk carries four carborundum cylinders, 2½-in. diameter and 2 in. thick, and is driven at about 800 r.p.m. In operation, the grooved wheels of the base ride on an 18-in. track of 1⅛-in. round



Wall-Surfacing Machine

rods resting on cast-iron ties 24-in. apart. The mechanism is inclosed and the weight of the machine complete is about 375 lb.

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Bandsaw for Portable Mills

A portable sawmill using a band instead of a circular saw has recently been placed on the market and opens great possibilities in reducing the waste and cost of lumbering. In sawing logs into boards with circular saws, from 20 to 25% of the lumber is converted into sawdust; the much thinner and truer-running bandsaw makes a kerf only one-third as wide as that made by a circular saw. Heretofore, however, band saws have only been operated in the large stationary sawmills; obviously for economical lumbering it is a great advantage to use portable mills moved from place to place in the woods instead of hauling the logs long distances to fixed mills. This mill has the mechanical novelty of holding stationary the log to be sawed while the bandsaw and carriage travel past. The outfit is claimed to have a minimum capacity of 13,000 ft. b.m. of 1-in. boards per day. A 50-hp. portable boiler generates sufficient steam to drive the mill. The outfit need not be dismantled at all for moving and can readily be hauled a half mile in two hours. This sawmill is being placed on the market by the Portable Band Saw Mill Co., 236 E. 87th St., New York City.